

**Dräger**medical

A Dräger and Siemens Company

# Operator's Instruction Manual

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## **Narkomed MRI-2 Anesthesia System**

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**WARNING:** For a full understanding of the performance characteristics of this anesthesia machine, the user should carefully read this manual before operating.

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# 1

## Introduction

*This section introduces you to the Narkomed MRI-2 Operator's Manual.*

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## **Operator's Responsibility for Patient Safety**

Draeger Medical anesthesia products are designed to provide the greatest degree of patient safety that is practically and technologically feasible. The design of the equipment, the accompanying literature, and the labeling on the equipment take into consideration that the purchase and use of the equipment are restricted to trained professionals, and that certain inherent characteristics of the equipment are known to the trained operator. Instructions, warnings, and caution statements are limited, therefore, to the specifics of the Draeger Medical design. This publication excludes references to hazards that are obvious to a medical professional, to the consequences of product misuse, and to potentially adverse effects in patients with abnormal conditions. Product modification or misuse can be dangerous. Draeger Medical disclaims all liability for the consequences of product alterations or modifications, as well as for the consequences that might result from the combination of Draeger Medical products with products supplied by other manufacturers if such a combination is not endorsed by Draeger Medical.

The operator of the anesthesia system must recognize that the means of monitoring and discovering hazardous conditions are specific to the composition of the system and the various components of the system. It is the operator, and not the various manufacturers or suppliers of components, who has control over the final composition and arrangement of the anesthesia system used in the clinical practice. Therefore, the responsibility for choosing the appropriate safety monitoring devices rests with the operator and user of the equipment.

Patient safety may be achieved through a variety of different means depending on the institutional procedures, the preference of the operator, and the application of the system. These means range from electronic surveillance of equipment performance and patient condition to simple, direct contact between operator and patient (direct observation of clinical signs). The responsibility for the selection of the best level of patient monitoring belongs solely to the equipment operator. To this extent, the manufacturer, Draeger Medical, disclaims responsibility for the adequacy of the monitoring package selected for use with the anesthesia system. However, Draeger Medical is available for consultation to discuss monitoring options for different applications.

## **Limitation of Liability**

Draeger Medical's liability, whether arising from or related to the manufacture and sale of the products, their installation, demonstration, sales representation, use, performance, or otherwise, including any liability based upon Draeger Medical's product warranty, is subject to and limited to the exclusive terms of Draeger Medical's limited warranty, whether based upon breach of warranty or any other cause of action

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## Disclaimer

The content of this manual is furnished for informational use only and is subject to change without notice. Draeger Medical, Inc. assumes no responsibility or liability for any errors or inaccuracies that may appear in this manual.

## Recommendations

In the interest of patient safety, Draeger Medical strongly advocates the use of an oxygen analyzer, pressure monitor, a volume monitor, and an end-tidal CO<sub>2</sub> monitor in the breathing circuit at all times.

Because of the sophisticated nature of Draeger Medical anesthesia equipment and its critical importance in the clinical setting, it is highly recommended that only appropriately trained and experienced professionals be permitted to service and maintain this equipment. Please contact DrägerService at (800) 543-5047 for service of this equipment.

Draeger Medical also recommends that its anesthesia equipment be serviced at three-month intervals. Periodic Manufacturer's Service Agreements are available for equipment manufactured by Draeger Medical. For further information concerning these agreements, contact DrägerService at (800) 543-5047.

## Symbol Definition

The following symbols appear on the labeling on the back of the Narkomed MRI-2 and are defined below.



**CAUTION:** Refer to accompanying documents before operating equipment.

**ATTENTION:** Consulter les documents ci-joints avant de faire fonctionner l'appareil.



**CAUTION:** Risk of electric shock, do not remove cover. Refer servicing to an authorized representative of DrägerService.

**ATTENTION:** Risque de choc électrique, ne pas enlever le couvercle. Ne faire réparer que par un représentant autorisé de DrägerService.



Degree of protection against electric shock: Class 1, Type B.

Protection contre le risque de choc électrique: Class 1, Type B.

## Purpose of This Manual

This manual provides operating instructions for the Narkomed MRI-2 Anesthesia System. It is intended for use by trained clinical professionals familiar with accepted medical procedures, practices, and terminology used in delivery of anesthesia and patient monitoring.

## How This Manual Is Organized

All users of the Narkomed MRI-2 must read this manual completely before using the machine. To make this document more convenient for future reference, it is divided into several independent sections.

*Section 2* - "General Description" on page 2-1 provides a summary of Narkomed MRI-2 features and functions.

*Section 3* - "Daily Checkout" on page 3-1 contains the checkout procedures that must be done on a daily basis.

*Section 4* - "Preuse Checkout" on page 4-1 contains the checkout procedures to be performed between successive cases.

*Sections 5 through 13* provide detailed instructions on the use and operation of each functional component of the system.

*Section 14* - "Routine Maintenance and Cleaning" on page 14-1 provides cleaning, maintenance, and replacement procedures.

*Section 15* - "Specifications" on page 15-1 lists the specifications for all system components.

## Conventions Used in This Manual

This manual has several conventions to help organize the information presented. Please read about these conventions carefully to understand their significance in the manual.

### Typefaces

Different typefaces are used throughout the manual to differentiate between narrative information and machine messages and labels.

### Warnings and Cautions

All parts of this manual contain warning and caution statements about the Narkomed MRI-2.

- *Warning* statements give important information that, if ignored, could lead directly to personal injury.
- *Caution* statements give important information that, if ignored, could lead directly to equipment damage and indirectly to personal injury.

## General Warnings and Cautions

The following list of warnings and cautions apply to general operation and maintenance of the Narkomed MRI-2. Warnings and cautions about installing and operating specific parts appear with those topics.

**WARNING:** The user of this anesthesia machine must comply with warnings, cautions, and checkout procedures printed on the machine or on the writing tray. Failure to do so may result in injury to the patient, operator, others, or equipment.

- WARNING:** Any person involved with the setup, operation, or maintenance of the Narkomed MRI-2 anesthesia system must be thoroughly familiar with this instruction manual.
- WARNING:** Do not place any object on this machine unless it is specifically labeled to be used in an MRI scanning room and on the Narkomed MRI-2 anesthesia system. Objects placed on this machine that are not designed for use with this anesthesia system may be strongly attracted to the magnet and may cause serious injury or death when the machine is used in an MRI scanning room.
- WARNING:** Always lock the casters after this anesthesia machine has been positioned in the MRI scanner room. Magnetic attractive forces between the magnet and the anesthesia machine may cause unintentional movement of the anesthesia machine if the casters are unlocked.
- WARNING:** The power supply charger assembly must not be taken into the magnet room. Damage to the equipment, MRI-2 system, or personal injury could result.
- WARNING:** This anesthesia machine has been tested only with magnets with field strengths of up to 3.0 tesla. Moving the machine near higher strength magnets (greater than 3.0 tesla) could result in machine malfunction or unmanageable attractive forces that could lead to serious injury or death.
- WARNING:** This anesthesia system will not respond automatically to certain changes in patient condition, operator error, or failure of components. The system is designed to be operated under the constant surveillance and control of a qualified operator.
- WARNING:** Use only nonmagnetic (aluminum) E-cylinders with this machine. Steel cylinders can cause serious injury or death if brought into an MRI scanning room.
- WARNING:** No third-party components shall be attached to the anesthesia machine, ventilator, or breathing system (except for certain approved exceptions). Contact DrägerService for further information.
- WARNING:** Not for use with flammable anesthetics. To avoid explosion hazards, do not use flammable anesthetic agents such as diethyl-ether and cyclopropane with this machine. Only anesthetic agents which comply with the requirements for non-flammable anesthetic agents per IEC standard or national equivalent shall be used with this anesthetic machine.

**WARNING:** When moving the anesthesia machine, remove the absorber system, and use only the machine handles or push/pull bars. The anesthesia machine should only be moved by people who are physically capable of handling its weight. Draeger Medical recommends that two people move the anesthesia machine to aid in maneuverability. Exercise special care so that the machine does not tip when moving up or down inclines, around corners, and across thresholds (for example, in door frames and elevators). Do not attempt to pull the machine over any hoses, cords, or other obstacles on the floor.

**WARNING:** Use manufacturer authorized replacement parts only. Failure to do so may result in machine malfunction, injury, or death.

**CAUTION:** The Narkomed MRI-2 is designed for MRI use only as a system. The user should not assume that individual components of the system can be safely used with MRI scanners.

**CAUTION:** Although the Narkomed MRI-2 is designed to minimize the effects of ambient radio-frequency interference, machine functions may be adversely affected by the operation of electrosurgical equipment or short-wave or microwave diathermy equipment in the vicinity.

**CAUTION:** Do not place any objects on top of the machine.

All the warnings and cautions above are provided below in French:

**AVERTISSEMENT:** L'utilisateur de l'appareil d'anesthésie doit se conformer aux avertissements, mises en garde et procédures de vérification imprimés sur l'appareil ou sur le panneau rétractable. Négliger de faire cela risque de provoquer des blessure chez le patient, l'opérateur ou d'autres personnes et risque également d'endommagement l'appareil.

**AVERTISSEMENT:** Toute personne chargée de la préparation, de l'utilisation ou de l'entretien de l'appareil d'anesthésie Narkomed MRI-2 doit très bien connaître le contenu de ce manuel d'utilisation.

**AVERTISSEMENT:** Ne placer aucun objet sur cet appareil à moins qu'il n'ait été spécifiquement approuvé pour l'utilisation dans une salle IRM avec un appareil d'anesthésie Narkomed MRI-2. Tout objet non conforme déposé sur cet appareil pourrait être fortement attiré par l'aimant et pourrait occasionner des blessures graves ou fatales lorsque l'appareil d'anesthésie est utilisé dans la salle IRM.

**AVERTISSEMENT:** Toujours bloquer les roues après avoir placé cet appareil d'anesthésie à l'endroit voulu dans la salle IRM. Les forces d'attraction magnétique entre l'aimant et l'appareil d'anesthésie peuvent provoquer un déplacement imprévu de ce dernier si les roues ne sont pas bloquées.

**AVERTISSEMENT:** Ne pas amener le chargeur de batterie dans la salle IRM car cela présenterait un risque d'endommagement du matériel et du système IRM, ou de blessure corporelle.

**AVERTISSEMENT:** Cette appareil d'anesthésie a été vérifiée avec des aimants possédant des champs magnétiques jusqu'à 3,0 tesla. Installé l'appareil près d'un aimant plus puissant (plus de 3,0 tesla) pourrait amener l'appareil à mal fonctionner ou produire des forces d'attractions incontrôlables qui pourrait causer des blessures sérieuses ou la mort.

**AVERTISSEMENT:** Ce système d'anesthésie ne réagit pas automatiquement à certains changements de l'état physiologique du patient, aux erreurs de l'opérateur ou aux défaillances des composants. Il a été conçu de manière à être utilisé sous le contrôle permanent de l'opérateur.

**AVERTISSEMENT:** Utiliser uniquement des bouteilles de type E non magnétiques (en aluminium) avec cet appareil. L'utilisation de bouteilles en acier dans la salle IRM pourrait occasionner des blessures graves ou mortelles.

**AVERTISSEMENT:** Ne pas utiliser de composants en provenance d'autres fabricants avec l'appareil d'anesthésie, le ventilateur ou le circuit d'anesthésie, à moins qu'ils n'aient été approuvés au préalable. Contacter DrägerService pour des informations complémentaires.

**AVERTISSEMENT:** Ne pas utiliser l'appareil d'anesthésie avec des anesthésiques inflammables. Pour éviter tout risque d'explosion, ne pas utiliser d'anesthésiques inflammables tels que l'éther et le cyclopropane. Seuls les anesthésiques conformes aux exigences relatives aux anesthésiques ininflammables de la norme CEI ou toute norme nationale équivalente pourront être utilisés avec cet appareil.

**AVERTISSEMENT:** Lors du déplacement de l'appareil d'anesthésie, retirer l'absorbeur et n'utiliser que les poignées ou les barres de poussée/traction. L'appareil d'anesthésie ne doit être déplacé que par des personnes suffisamment fortes pour en supporter le poids. Draeger Medical recommande que deux personnes déplacent l'appareil d'anesthésie afin de le manœuvrer plus facilement. Veiller à ce que l'appareil ne bascule pas lors du déplacement sur des plans inclinés, dans des angles et au passage de seuils (portes et ascenseurs, par exemple). Ne pas faire passer l'appareil sur des tuyaux, des fils électriques ou d'autres obstacles se trouvant sur le sol.

**AVERTISSEMENT:** Utiliser seulement des pièces de remplacement fournies par le fabricant. Des pièces non approuvées peuvent causer des problèmes de fonctionnement, des blessures ou la mort.

**ATTENTION:** L'appareil d'anesthésie Narkomed MRI-2 doit être utilisé uniquement en tant que système pour l'imagerie à résonance magnétique. L'utilisateur ne doit pas présumer que chaque composant du système peut être utilisé seul pour l'IRM sans présenter de risques.

**ATTENTION:** Bien que l'appareil d'anesthésie Narkomed MRI-2 soit conçu de manière à minimiser le parasitage électromagnétique, son fonctionnement peut être affecté par l'utilisation de générateurs d'électrochirurgie ou d'appareils de diathermie à ondes courtes ou d'appareils à micro-ondes se trouvant aux alentours.

**ATTENTION:** Ne pas placer des objets sur l'appareil.

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# 2

## General Description

*This section provides you with a general description of the Narkomed MRI-2 anesthesia machine.*

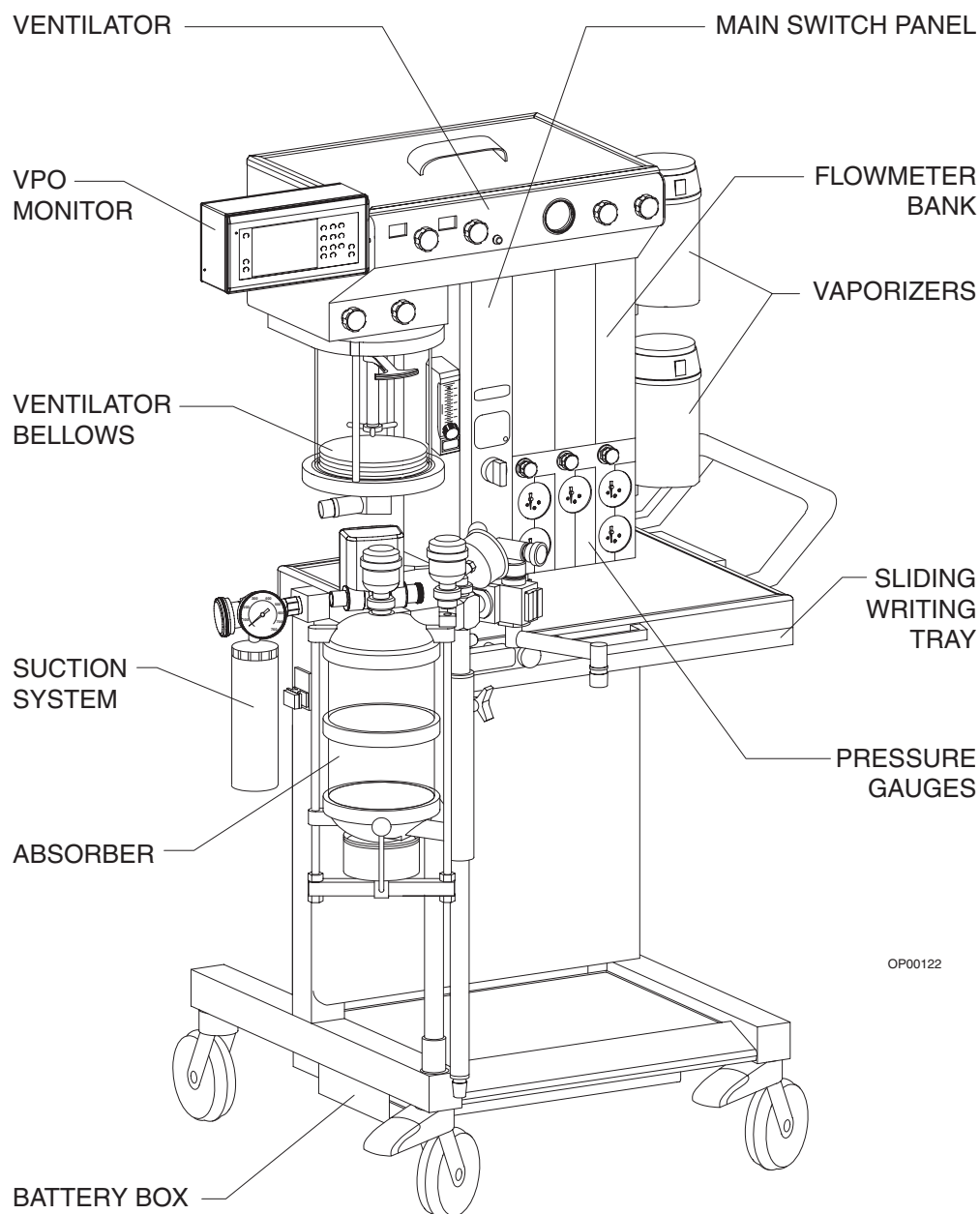
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## Overview

The Narkomed MRI-2 is a continuous flow anesthesia system used for spontaneous, manually assisted, or automatic ventilation; delivery of gases and anesthetic vapor; and monitoring oxygen concentration, breathing pressure, and respiratory volume. The Narkomed MRI-2 can be used in MRI scanner rooms with magnets of 3.0 tesla or less.

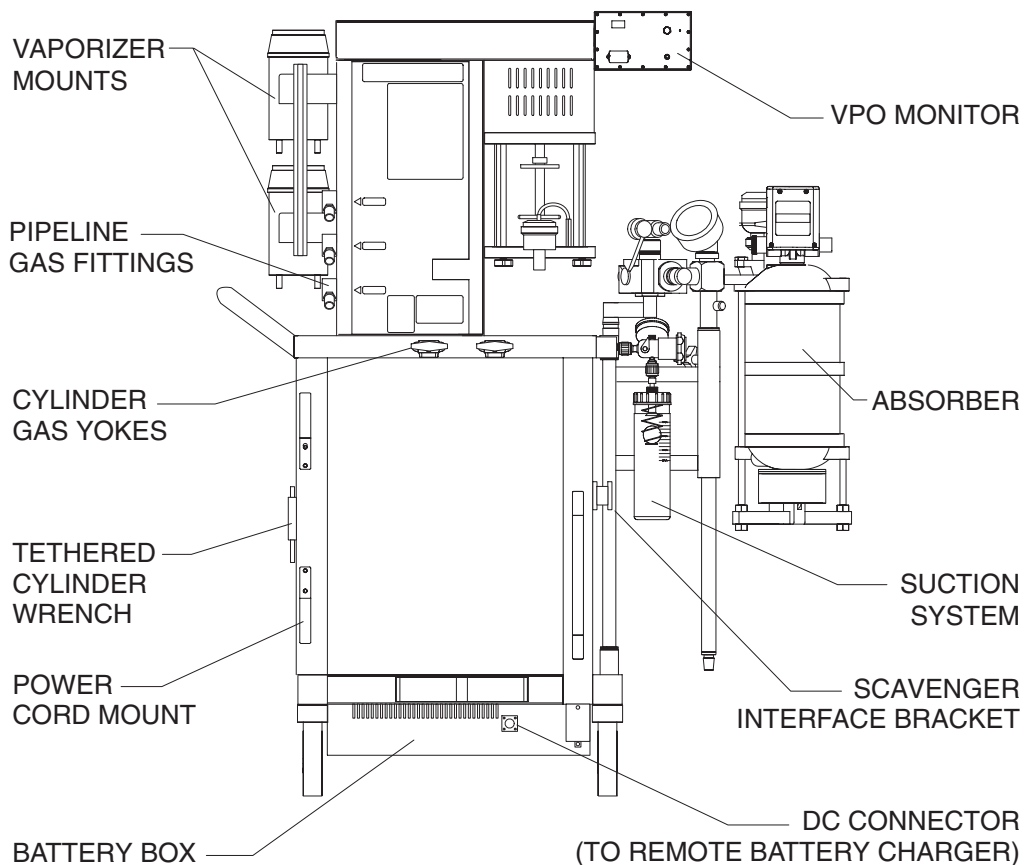
A front view is shown in the figure below.

**Figure 2-1. Narkomed MRI-2 Front View**



A back view is shown in the figure below.

**Figure 2-2. Narkomed MRI-2 Back View**



OP00615

## Gas Delivery System

The pneumatic system can simultaneously deliver up to three gases and one anesthetic agent. Gas is supplied to the system through pipelines and cylinders. Pipeline connections for oxygen, air, and nitrous oxide are standard. Gas cylinder yokes are provided for one oxygen cylinder and one nitrous oxide cylinder.

**WARNING:** Use only nonmagnetic (aluminum) E-cylinders with this machine. Steel cylinders can cause serious injury or death if brought into an MRI scanning room.

**Color Coding** Each connection, valve, gauge, and flowmeter is labeled and color-coded for the appropriate gas as shown in the table below.

**Table 2-1. Gas System Color Coding**

GAS	MARKING	USA	ISO
Air	AIR	Yellow	Black/White Checkered
Nitrous Oxide	N <sub>2</sub> O	Blue	Blue
Oxygen	O <sub>2</sub>	Green	White

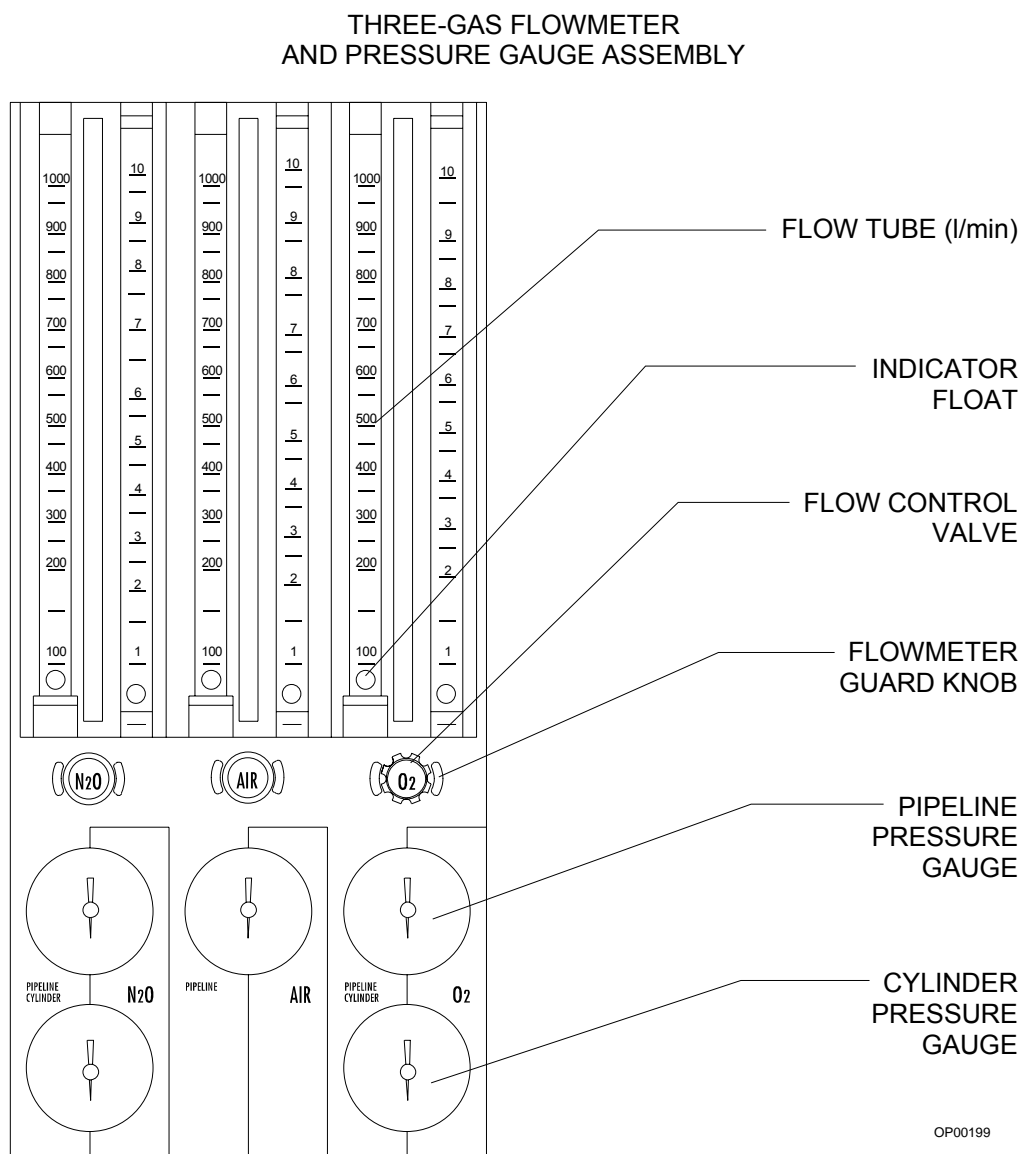
## Gas Entry Through the Pipeline

Gas from the hospital pipelines enters the Narkomed MRI-2 through hoses connected to indexed pipeline inlets located on the side of the flowmeter housing. The indexed connector system reduces the risk of delivering the wrong gas to a patient by preventing incorrect connection of gas pipes. The inlets have check valves, which prevent backflow leakage into the atmosphere (when supply hoses are not connected) or into the attached supply hoses (when reserve cylinders are in use). Each pipeline connection is equipped with a filter to prevent foreign material from entering the internal gas piping. Pipeline gases must be supplied at 50–55 psi.

## Pipeline Pressure Gauges

Pipeline pressure gauges for oxygen, air, and nitrous oxide are standard. These gauges are located directly below their corresponding flowmeters and flow control valves. They are labeled and color-coded for their respective gases on the flowmeter shield. Concentric scales in psi and kPa indicate the pipeline supply pressure. A typical pressure gauge and flowmeter arrangement is shown in the following figure.

Figure 2-3. Pressure Gauge and Flowmeter Arrangement



When the machine is connected to an active pipeline supply, each gauge must indicate 50–55 psi. A deviation from this range indicates that the pipeline gas supply system is improperly adjusted and may adversely affect operation. A fluctuating pipeline supply pressure, for example, would cause a corresponding fluctuation in the gas flow delivered from that pipeline. An excessively low pipeline pressure may activate the corresponding reserve cylinder and deplete its contents (if the reserve cylinder valve was left in the open position).

**CAUTION:** To ensure that gas supplies are at adequate pressure, pipeline pressure gauges must indicate steady pressures of 50–55 psi.

## Gas Entry Through Cylinder Yokes

The Narkomed MRI-2 is equipped with one oxygen cylinder and one nitrous oxide cylinder hanger yoke located in back of the machine. To prevent a cylinder from being improperly connected, the yokes are labeled, color-coded, and keyed for gas-specific cylinders using a pin-indexed safety system.

A filter in each yoke prevents foreign material from entering the internal gas piping. A check valve in each yoke prevents backflow into the cylinder or leakage into the atmosphere if the cylinder is not mounted on the yoke. Place the attached yoke plug between the yoke handle's threaded bolt and the yoke's gas inlet.

When attaching a cylinder, make sure that only one washer is installed between the cylinder and the yoke gas inlet. Using multiple washers may compromise the pin-indexed safety system. Be sure to verify the integrity of both index pins when installing a new cylinder.

**WARNING:** Check the cylinder yokes to make sure the two index pins are intact each time you attach a cylinder to the machine. Use only one cylinder gasket for each yoke. Using more than one gasket could cause cylinder gas leakage and compromise the pin-indexed safety system.

Cylinders attached to the hanger yokes must contain gas at the recommended pressures outlined in the table below. Replace any cylinders that contain less than the recommended minimum shown in the table with new, full cylinders.

**WARNING:** Use only nonmagnetic (aluminum) E-cylinders with this machine. Steel cylinders can cause serious injury or death if brought into an MRI scanning room.

**Table 2-2. Cylinder Recommended Gas Pressure**

GAS	PSI - FULL	PSI - MIN
Nitrous Oxide	745	600
Oxygen	1900	1000

Indicated pressures are those of E-size cylinders at 70°F (21°C).

## Cylinder Pressure Gauges

Each cylinder gas circuit has a cylinder pressure gauge, located at the bottom of the flowmeter panel on the front of the machine (see the Flowmeter and Pressure Gauge Assembly figure shown earlier in this section.) Each gauge is labeled and color-coded on the flowmeter housing for its respective gas. When a cylinder valve is open, the pressure gauge indicates the cylinder gas pressure. The dial is marked with concentric scales for psi and kPa.

For a nonliquefied gas such as oxygen, the indicated pressure is proportional to the gas content of the cylinder. For a liquefied gas such as nitrous oxide, the gauge indicates the vapor pressure of the liquefied gas in the cylinder. This pressure remains constant until all of the liquid in the cylinder is vaporized. When the liquid is vaporized, the cylinder pressure decreases proportionally as gas is removed from the cylinder.

## Oxygen Supply Pressure Failure Protection Device (OFPD)

The oxygen failure protection device (OFPD) is a pneumatically operated valve that protects the patient if a partial or complete loss of oxygen pressure occurs. The valves are located in the internal supply lines for all gases except oxygen. The gas pressure in the oxygen supply line controls the valves. When the oxygen pressure is adequate, the valves remain open with an unrestricted gas flow. Oxygen pressure loss causes the valves to close proportionally to the loss of pressure. As a result, OFPD-controlled gases can be restricted or shut down in response to loss of oxygen pressure.

Gas flow reductions are indicated on the flowmeter. When the oxygen supply from the pipeline or reserve cylinders drops below about 37 psi, the red O<sub>2</sub> SUPPLY PRESSURE indicator light on the main switch panel lights, the LO O<sub>2</sub> SUPPLY message appears on the monitor, and a continuous audible alarm sounds.

If only one source of oxygen supply pressure (either reserve cylinders or pipeline) fails and the other source maintains proper supply pressure within the machine's oxygen supply lines, the OFPD and LOW O<sub>2</sub> SUPPLY alarm are not activated.

## Flowmeters

The flowmeters are located directly above their corresponding flow control valves. They indicate the delivered flow rate of each gas in the fresh gas mixture. Dual-tapered flowmeter tubes are used for oxygen, nitrous oxide, and air. All flowmeters are labeled at the lower end of the flowtube. A typical flowmeter arrangement appears in the Flowmeter and Pressure Gauge Assembly figure shown earlier in this section.

Each flowmeter has a float indicator. To determine the flow rate, read the flowmeter scale at the center of the float.

## Minimum Oxygen Flow

The oxygen dispensing system has a calibrated bypass flow of 150 ±50 ml/min (at 50 psi pipeline pressure), which delivers this volume of oxygen even if the oxygen flow control valve is fully closed.

### Flow Control Valves

A needle valve is located below the flowmeter tube for each gas. This valve is used to adjust the flow of gas. Turning the valve knob counterclockwise increases flow. Turning the knob clockwise decreases flow. A zero-stop prevents damage to the flow control valve seats. If necessary, an authorized representative of DrägerService can readjust the stop.

Each flow control knob is identified by its color code and chemical symbol. The oxygen flow control valve is also touch-coded with a deeply fluted knob.

**CAUTION:** The flow of oxygen cannot be completely shut off (see “Minimum Oxygen Flow” on page 2-7). Do not force the oxygen flow control knob to shut off the minimum flow. Forcing the knob can damage the valve seat.

### Oxygen Flush

A manually operated, self-closing, oxygen flush valve is located on the front of the machine. A bezel is mounted around the pushbutton to prevent accidental engagement. When actuated, the valve delivers an unmeasured oxygen flow of approximately 55 l/min directly to the fresh gas common outlet. The SYSTEM POWER switch does not have to be in the ON position to use the oxygen flush.

### Oxygen Ratio Controller (ORC)

The ORC is a pneumatic oxygen/nitrous oxide interlock system designed to maintain a fresh gas oxygen concentration of  $25 \pm 4\%$ . It provides independent control of the oxygen and nitrous oxide flows.

The ORC works by proportionally limiting the nitrous oxide flow whenever the selected oxygen and nitrous oxide flow control valve settings would otherwise result in a hypoxic fresh gas mixture. For example, if you open the nitrous oxide flow control valve excessively without making a corresponding increase in the oxygen flow control valve setting, the nitrous oxide flow will not increase even though its flow control valve setting was greatly increased. Similarly, if you decrease the oxygen flow without also decreasing the nitrous oxide flow, the nitrous oxide flow automatically drops in proportion to the oxygen flow.

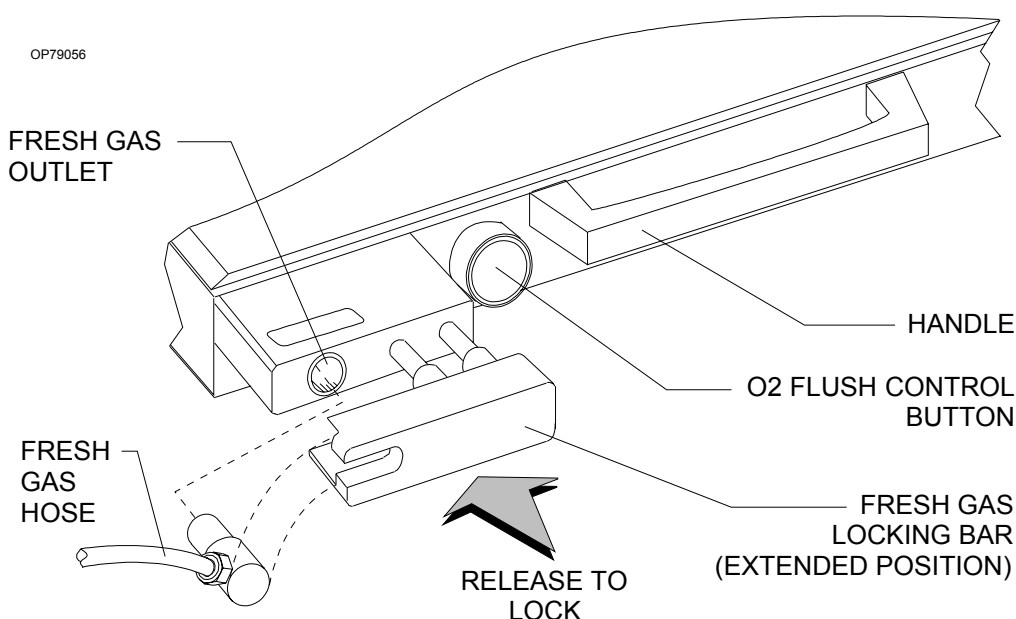
**WARNING:** In circle systems, the gas mixture in the patient circuit is not necessarily the same as that in the fresh gas flow. This is particularly true at low fresh gas flow rates when the patient rebreathes a significant portion of previously exhaled gases. It is important to monitor the gas mixture in the patient circuit and to adjust the fresh gas flow to meet the patient's requirements and to compensate for patient uptake, system leakage, or any gas withdrawn through sample lines and not returned.

### Fresh Gas Outlet (15 mm)

The fresh gas outlet delivers the fresh gas mixture consisting of oxygen, nitrous oxide, air, and vapors of a liquid anesthetic to the patient breathing system. It is located on the front of the anesthesia machine.

The outlet's 15 mm cylindrical female fitting is designed to accept a 15 mm male fitting on the absorber fresh gas hose. The male fitting slides into a retaining slot in the spring-loaded safety locking bar to prevent the fresh gas hose from being disconnected accidentally. The 15 mm male fitting on the fresh gas hose is unique to Draeger Medical design and should not be replaced by a hose from any other manufacturer.

Figure 2-4. Fresh Gas Outlet (15 mm)



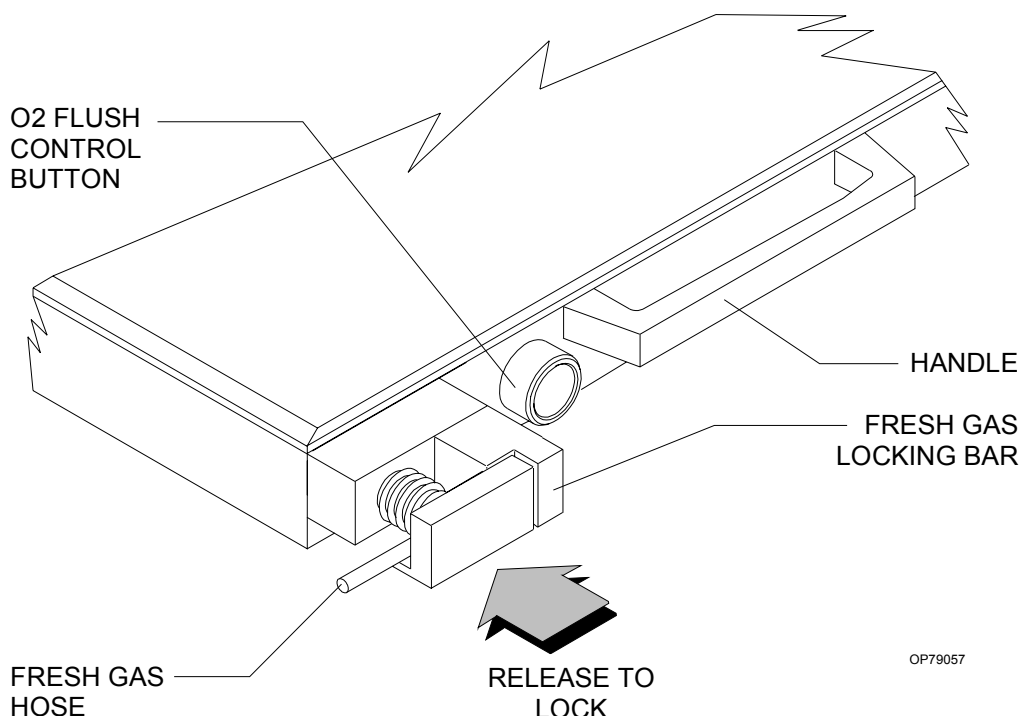
**Fresh Gas Outlet  
(15 mm /  
22 mm)**

The fresh gas outlet delivers the fresh gas mixture consisting of oxygen, nitrous oxide, air, and vapors of a liquid anesthetic to the patient breathing system. It is located on the front of the anesthesia machine.

The outlet has a dual fitting to accommodate:

- a 15 mm male fresh gas hose fitting, such as those supplied with Draeger Medical absorbers and Bain circuit adapters. When using a 15 mm fitting, place the spring-loaded locking bar over the male fitting to secure it to the female fitting.
- a 22 mm female fitting with a load-bearing threaded mount, such as the ones for Magill circuits or ISO-type nonrebreathing adapters. When using an ISO-type nonrebreathing adapter, swing the spring-loaded locking bar to the side to gain access to the threaded load-bearing fitting.

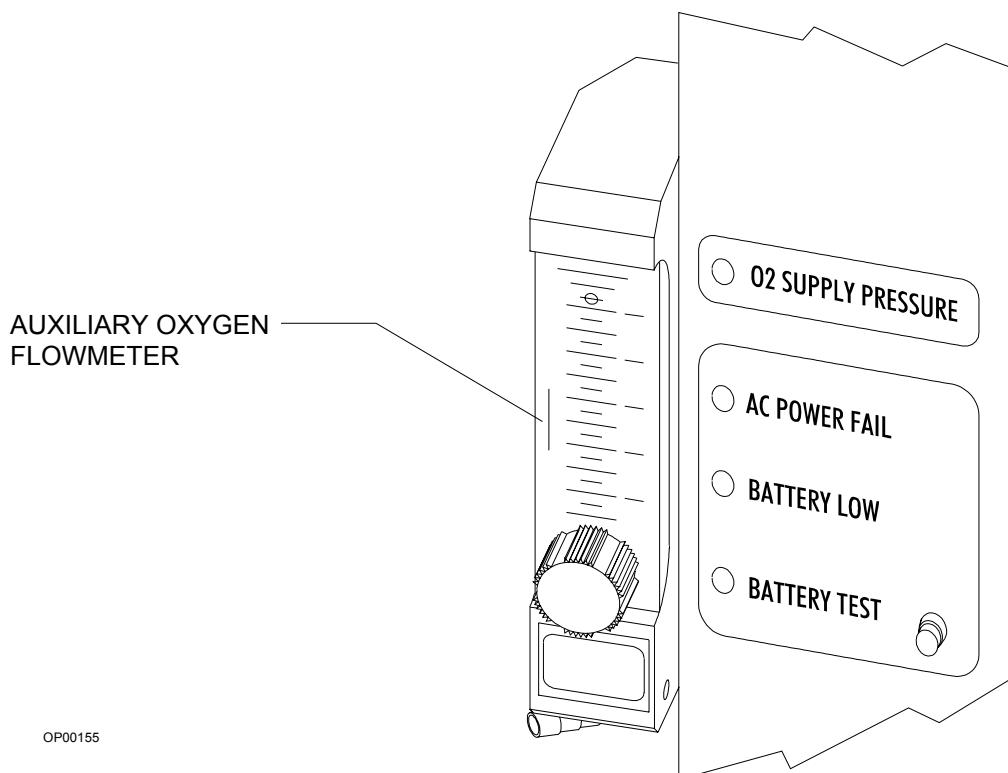
**Figure 2-5. Fresh Gas Outlet (15 mm / 22 mm)**



### Auxiliary Oxygen Flowmeter

To deliver a metered flow of pure oxygen (for example, delivery of oxygen through a nasal cannula), an auxiliary oxygen flowmeter is mounted on the left side of the main switch panel. This flowmeter can be used when the machine is turned off. A zero-stop prevents damage to the flow control valve seat.

Figure 2-6. Auxiliary Oxygen Flowmeter



## Vaporizers

The Narkomed MRI-2 can be equipped with up to two vaporizers for administering liquid anesthetics. For complete information, see the appropriate separate manual that is supplied with vaporizers available for use with the Narkomed MRI-2.

### Exclusion System

The Narkomed MRI-2 is equipped with a vaporizer exclusion system.

The purpose of the exclusion system is to prevent more than one vaporizer from being activated at a time. The exclusion system is incorporated into the vaporizer bank and requires the unused vaporizer to be locked in the zero percent position.

**WARNING:** Only one vaporizer can be activated at a time. If the exclusion system permits simultaneous activation of more than one vaporizer, do not use the anesthesia machine. Contact an authorized representative of DrägerService for adjustment.

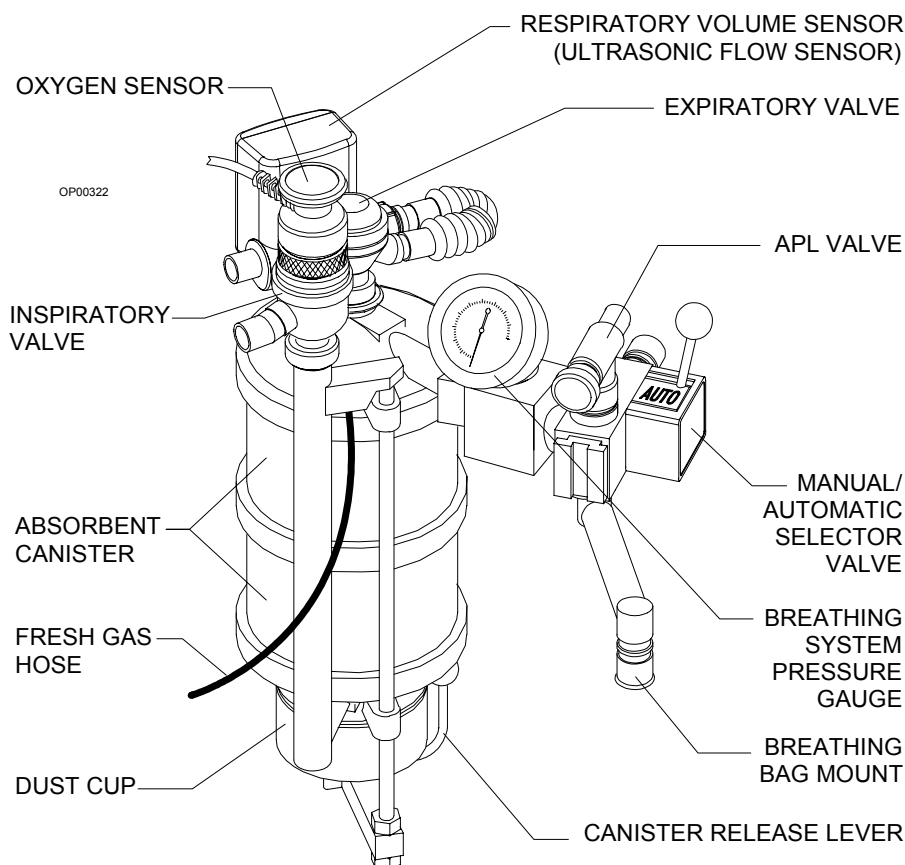
### Handling the Vaporizer

If a vaporizer is dropped during handling, or if its handwheel exhibits a lack of resistance (spins freely), or if a gas analyzer maintains a zero reading after the handwheel has been turned to a labeled concentration, do not use the vaporizer. Return the vaporizer to DrägerService.

## Absorber

An absorber system is available for absorbing exhaled carbon dioxide in the rebreathing circuit of the anesthesia machine. It incorporates an adjustable pressure limiter (APL) valve, a breathing system pressure gauge, a fresh gas line, and connections for sensing breathing pressure, respiratory volume, frequency, and oxygen concentration.

Figure 2-7. Absorber System



The absorber system is designed for spontaneous, manually assisted, or automatic ventilation. The absorber system has a manual/automatic selector valve for selecting manual or automatic ventilation.

**WARNING:** Waste gas scavenging systems used with Draeger Medical absorber systems must have safety features to ensure that excessive subatmospheric pressure (lower than  $-0.5 \text{ cmH}_2\text{O}$ ) and excessive positive pressure (higher than  $+0.5 \text{ cmH}_2\text{O}$ ) are not possible at the connection point.

## Inspiratory and Expiratory Valves

The inspiratory and expiratory valves control the direction of gas flow in the absorber system. The inspiratory valve is labeled INSPIRATION and the expiratory valve is labeled EXPIRATION.

The valves are unidirectional, permitting gas flow in one direction only:

- The inspiratory valve allows gas to flow toward the patient only, with no backflow to the absorber.
- The expiratory valve allows gas to flow into the absorber only, with no backflow to the patient.

The valves are *not* interchangeable. They must be connected to the correct mounts for the proper flow direction through the absorber system.

Different size mounting threads on each valve prevent connecting a valve to the wrong mount.

**WARNING:** Do not use the inspiratory or expiratory valves if:

- the pins in the plastic valve domes or in the valve bodies are bent, damaged, or missing,
- the valve disks are missing or damaged, or
- the valve seat is damaged.

## Canister

Each absorber unit has two transparent plastic canisters to contain absorbent. The absorbent (soda lime or barium hydroxide lime) can be purchased in loose granular or prepacked cartridge form. The canisters are interchangeable.

## Dust Cup

A removable, transparent plastic cup located below the bottom assembly collects absorbent dust and excess moisture that could cause increased flow resistance in the system.

## Breathing System Pressure Gauge

The absorber system is equipped with a pressure gauge for quick visual checks of breathing circuit pressure. The gauge is marked for measurements from -20 to +80 cmH<sub>2</sub>O in increments of 2 cmH<sub>2</sub>O.

**WARNING:** You must frequently observe the breathing system pressure gauge to ensure adequate pressure buildup and relief, regardless of the mode of operation.

**CAUTION:** Only the pressure gauge supplied with a Narkomed MRI-2 should be used.

## Peep Valve Option

**NOTE:** The PEEP valve option described in the Absorber System Operator's Manual is not available for Narkomed MRI-2 products.

## Bain Circuit Adapters

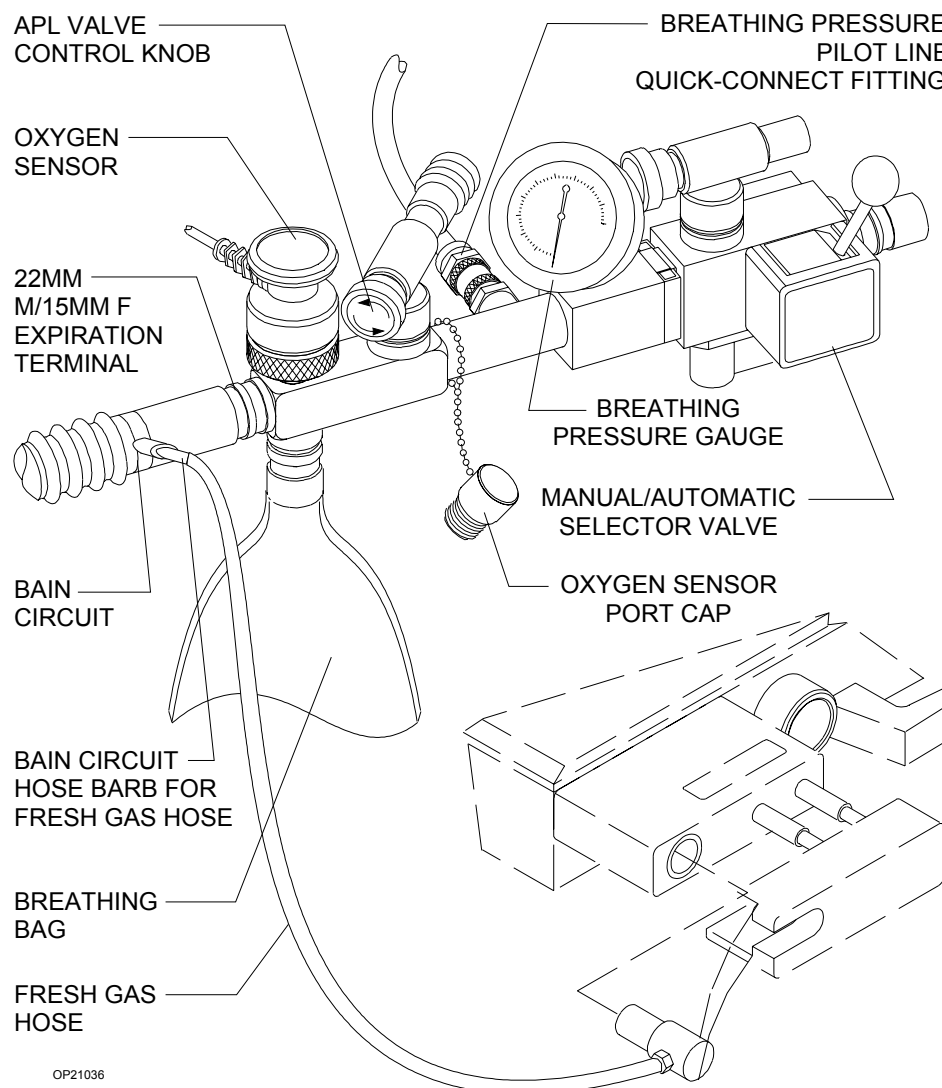
Two types of Bain circuit adapters are available. One mounts to the absorber; the other mounts to the absorber pole.

**CAUTION:** Only the breathing pressure gauge supplied with a Narkomed MRI-2 Bain circuit adapter should be used.

### Absorber Mount

The absorber-mounted Bain circuit adapter, shown in Figure 2-8, mounts onto the manual/automatic selector valve of the absorber system. The adapter includes an adjustable pressure limiter (APL) valve, a breathing pressure gauge, a quick-connect fitting for the breathing pressure pilot line, a port for the oxygen sensor, a 15/22 mm port for non-rebreathing circuits, and a connector for a patient breathing bag.

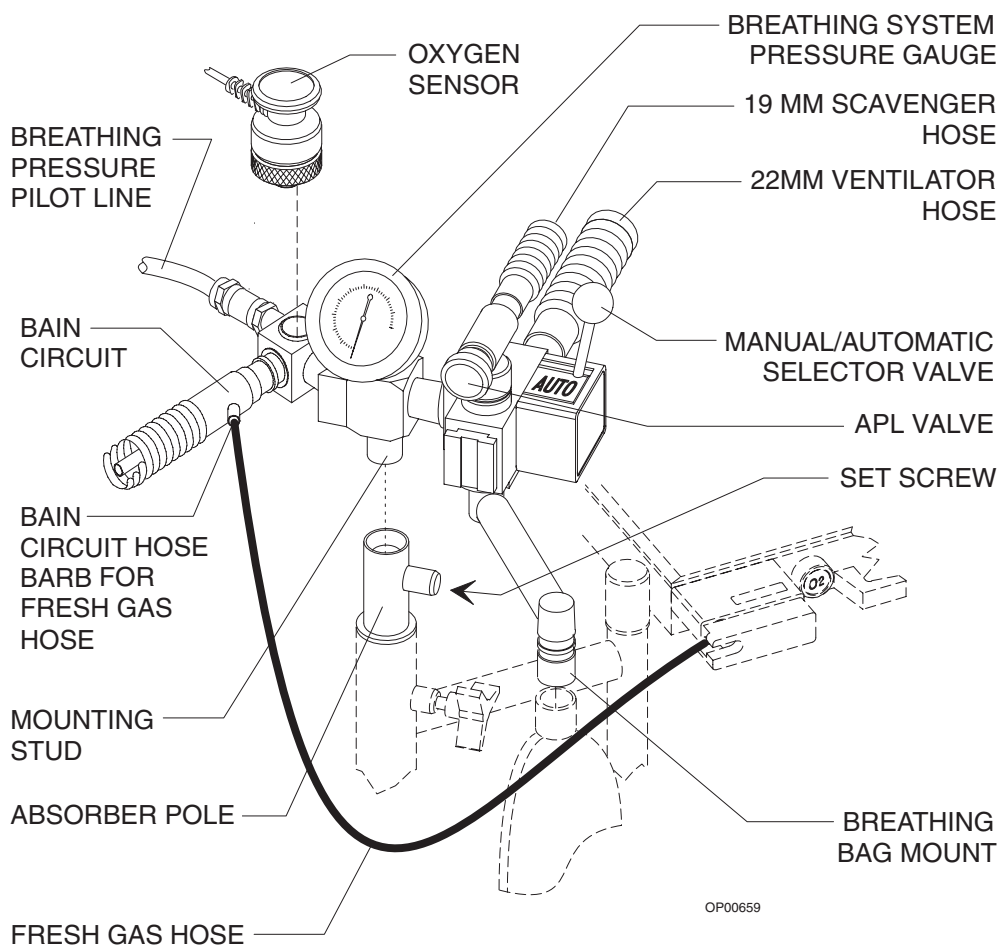
Figure 2-8. Absorber Mount Bain Circuit Adapter



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**Pole Mount** The pole-mounted Bain Circuit adapter, shown in Figure 2-9 , mounts on the absorber pole.

**Figure 2-9. Pole Mount Bain Circuit Adapter**



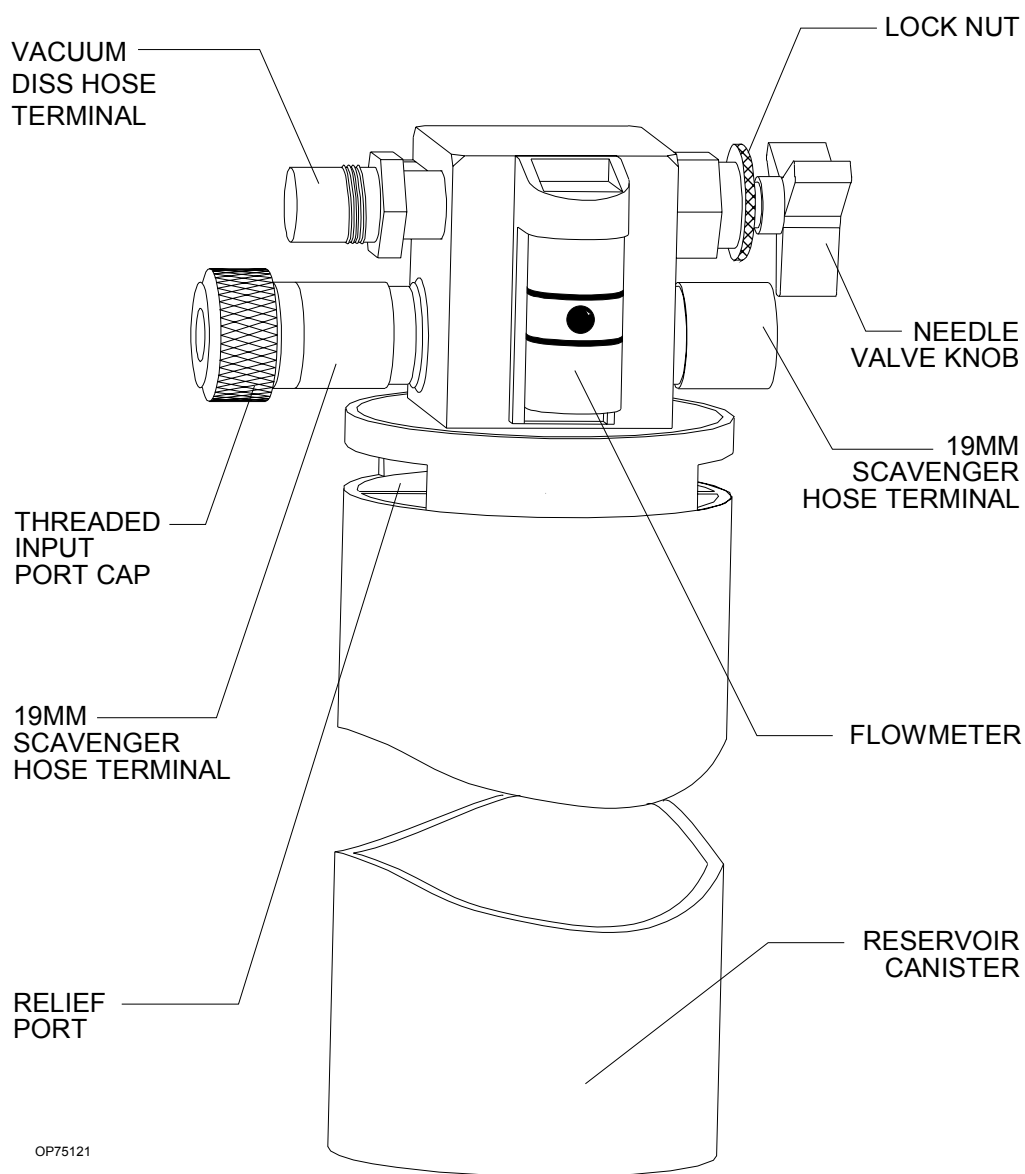
## Scavenger Systems

The Narkomed MRI-2 can be equipped with one of two kinds of scavenger systems for the best match with the hospital's waste gas disposal system.

### Open Reservoir Scavenger

The open reservoir scavenger is used with suction (vacuum) waste gas disposal systems. This scavenger is an "open" system with continually open relief ports for positive and negative pressure control.

Figure 2-10. Open Reservoir Scavenger

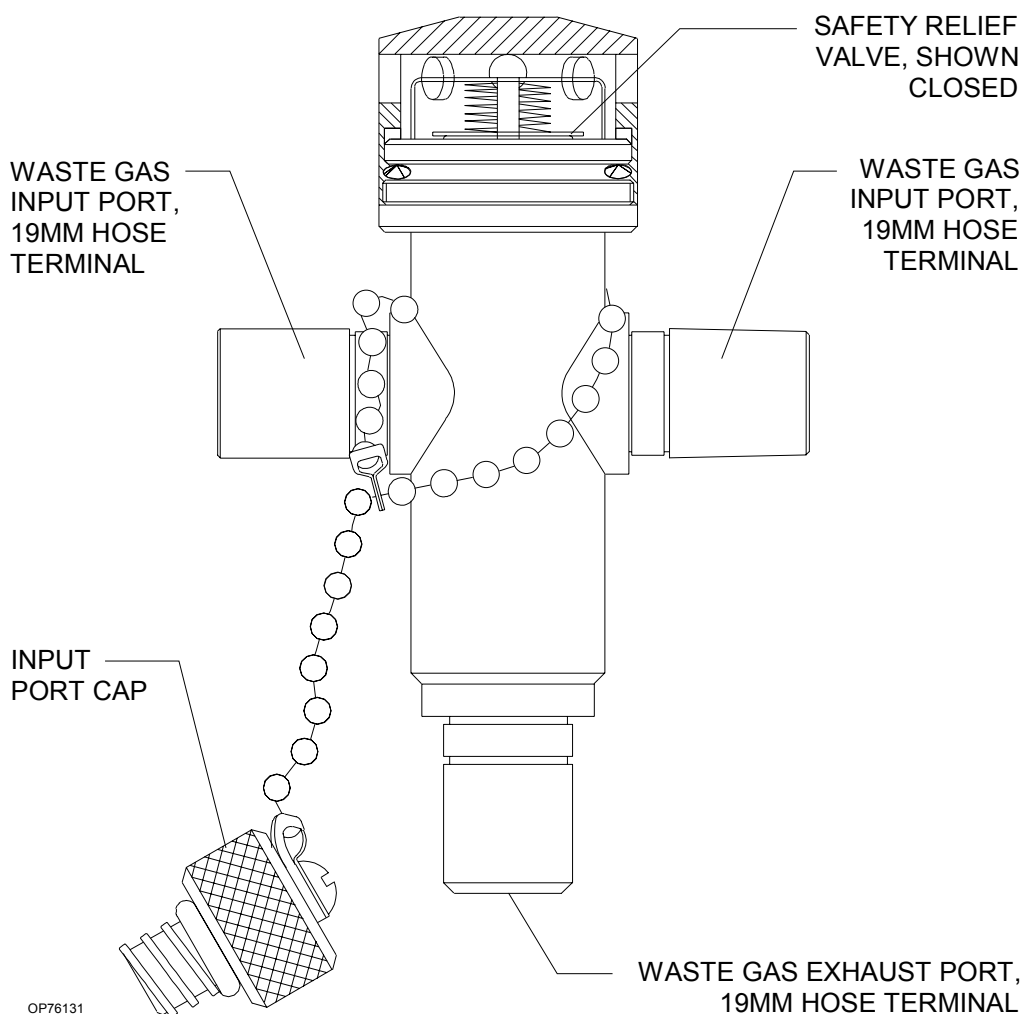


### Scavenger Interface for Passive Systems

The scavenger interface for passive systems is used with nonrecirculating HVAC systems (exhaust systems). This scavenger is a “closed” system, with a spring-loaded valve for positive pressure relief.

**WARNING:** Do not use this device with a waste gas disposal system capable of applying a negative pressure to the scavenger interface (a suction or vacuum waste gas disposal system).

Figure 2-11. Scavenger Interface for Passive Systems

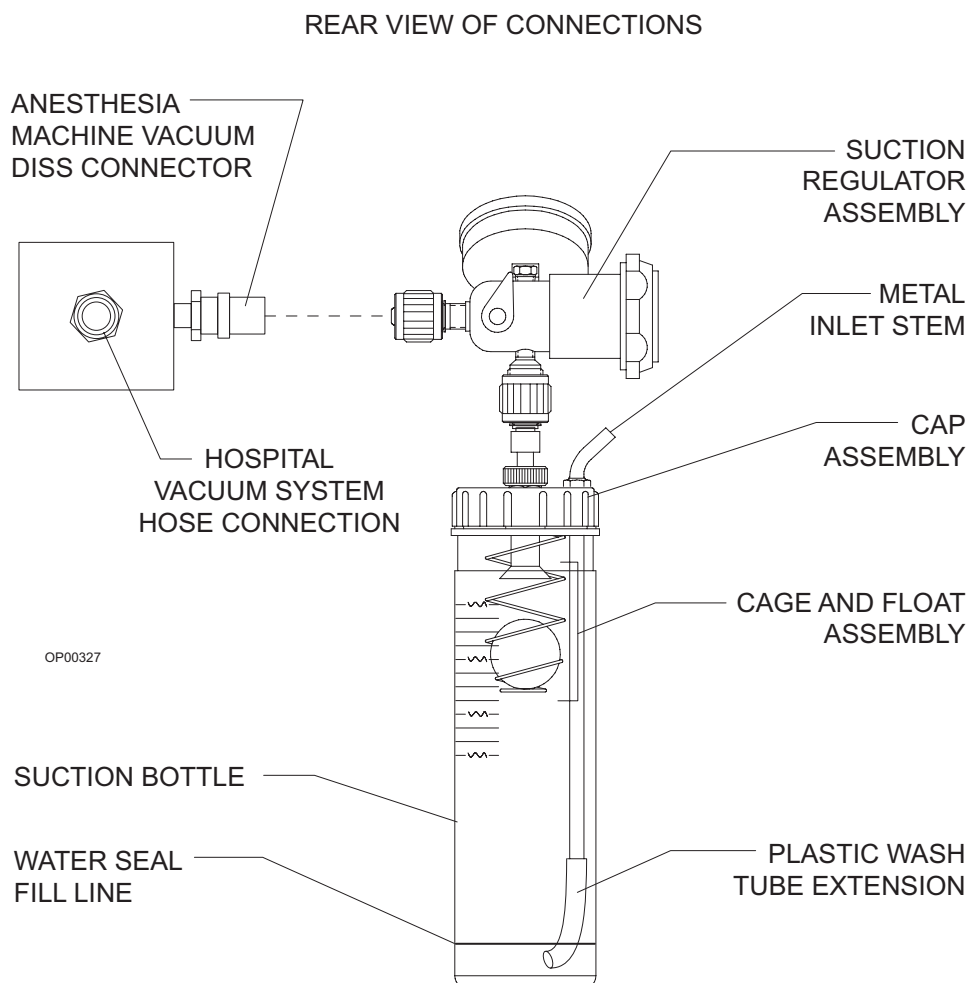


## Tracheal Suction System

The tracheal suction system on the Narkomed MRI-2 is designed for aspirating mucus, blood, and other patient drainage fluids from the upper respiratory tract. It consists of a fluid collection receptacle and a suction regulator that attaches to the vacuum DISS connector on the side of the machine. For complete information, see the manufacturer's instructions supplied with the suction system assembly.

**WARNING:** Do not apply unregulated suction to the patient circuit when using this device.

Figure 2-12. Tracheal Suction System - Rear View



## AV2+ Ventilator

The AV2+ anesthesia ventilator is a volume-preset, time-cycled, pressure-limited ventilator with electronic timing, pneumatic circuitry and independent controls for frequency, inspiratory-to-expiratory (I:E) ratio, inspiratory flow rate, tidal volume, and inspiratory pressure limit.

Pneumatic power (bellows drive gas) to the ventilator is supplied through the hospital oxygen pipeline supply or through the reserve cylinder on the anesthesia machine. The supply gas pressure must be between 40 and 60 psi. The ventilator will not function properly if this pressure drops below 32 psi. Electrical power is supplied by the AC power source or by the battery. A fully charged battery can power the ventilator for up to three hours.

The anesthesia ventilator, designed for use with a Draeger Medical absorber system, has a manual/automatic selector valve. Use this valve to select the breathing bag and adjustable pressure limiter (APL) valve for manual ventilation or the ventilator bellows for automatic ventilation.

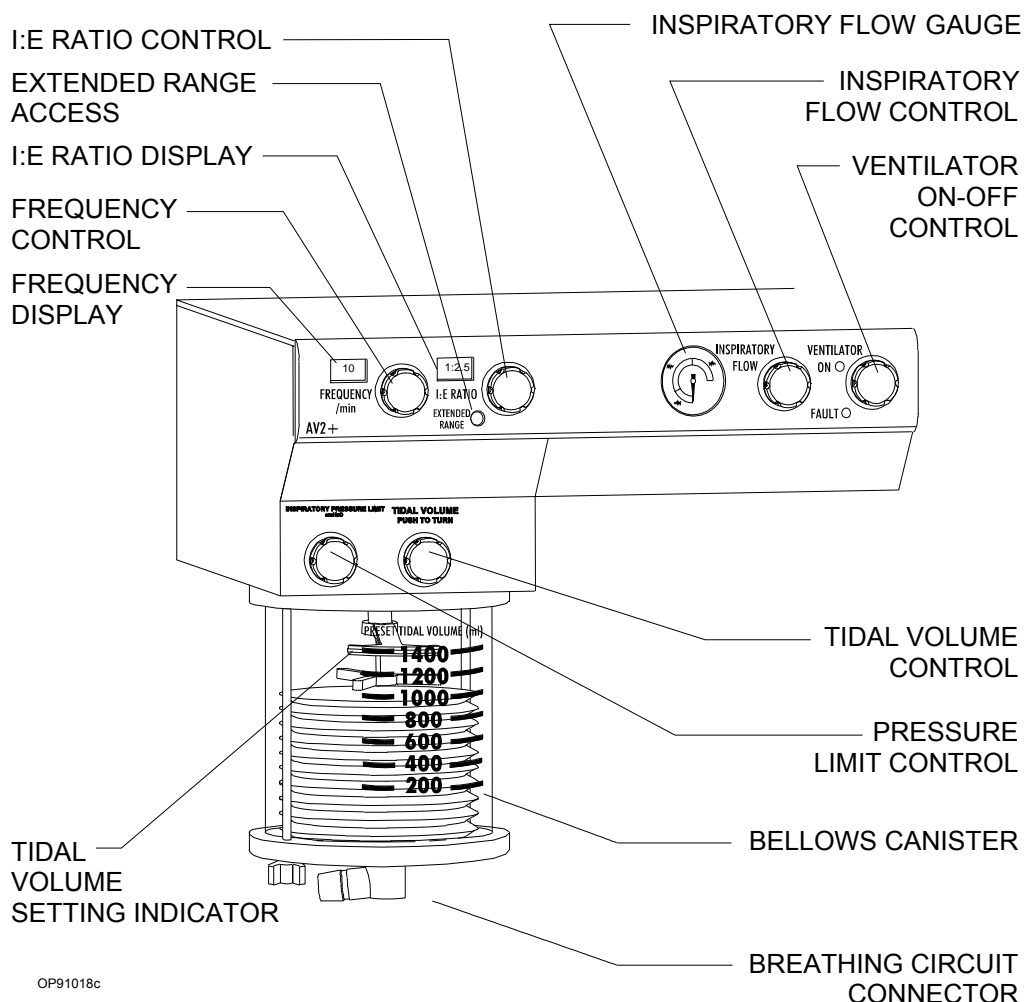
During automatic ventilation, the manual/automatic selector valve isolates the APL valve from the breathing system. The ventilator has a relief valve mounted behind the bellows chamber to compensate for introducing continuous fresh gas into the breathing system.

When the bellows is completely filled, any excess gas in the system is released to the scavenger system through the ventilator relief valve. As in any ascending bellows, the force needed to overcome gravity acting on the bellows causes a positive end-expiratory pressure (PEEP) within the breathing system. The PEEP is about 2 cmH<sub>2</sub>O.

The pressure limit control is used to set the peak inspiratory pressure produced by the ventilator to prevent barotrauma. The pressure limit control can also improve ventilation for patients with reduced lung compliance (neonatal/pediatric patients and patients with adult respiratory distress syndrome), because it limits the peak inspiratory pressure during the inspiratory phase of ventilation.

The AV2+ ventilator is shown in the following drawing.

Figure 2-13. AV2+ Ventilator



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## Main Switch Panel

The main switch panel is located between the ventilator bellows and flowmeter bank.

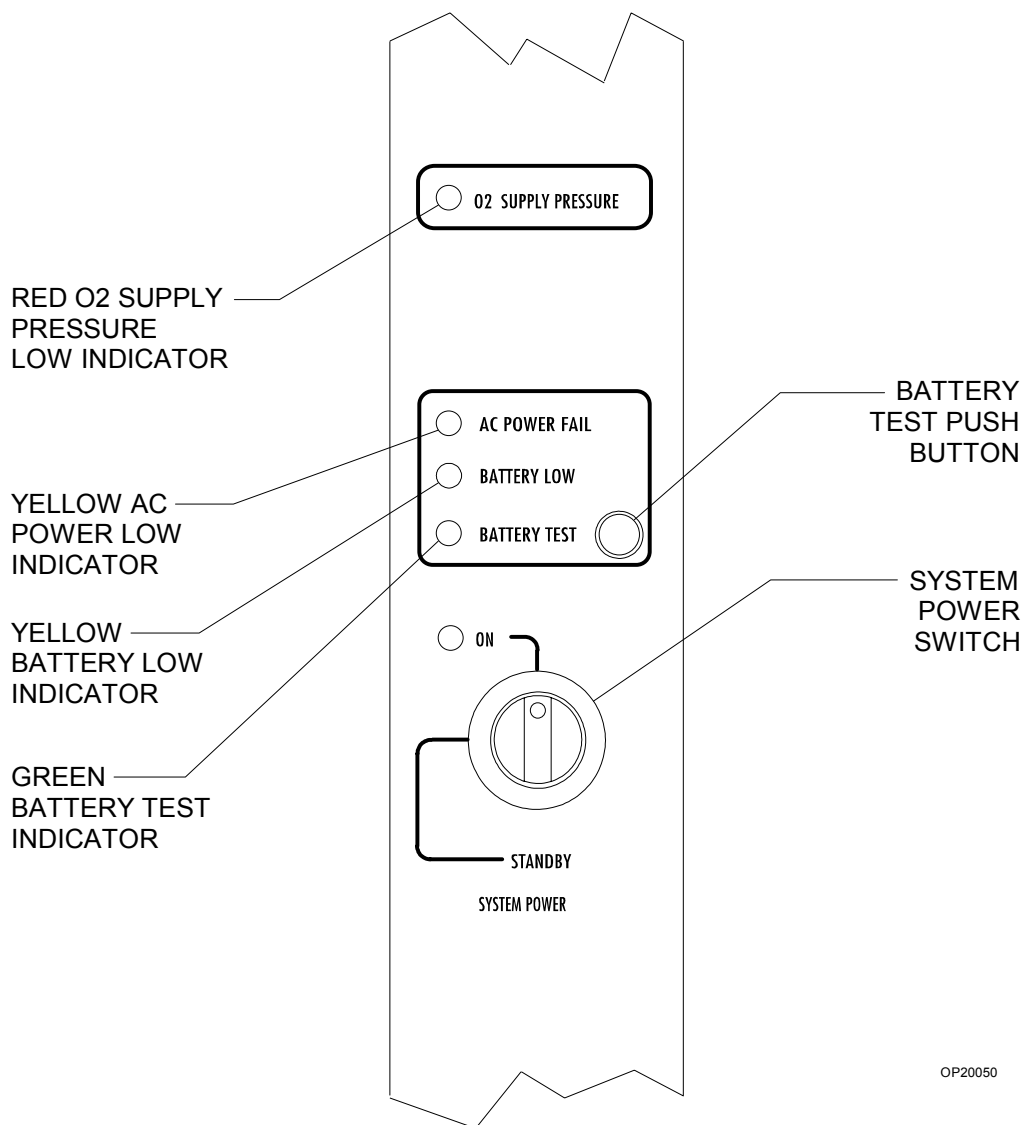
### System Power Switch

The SYSTEM POWER switch has two positions; ON and STANDBY. In the ON position, the gas (pneumatic) and electric power circuits for the ventilator and alarm circuits are on. The green indicator next to the switch lights. In the STANDBY position, the switch shuts down the gas supplies and all electrical power to the machine. The battery charging circuit remains on.

### AC Power Failure Indicator

The yellow AC POWER FAIL indicator (AC PWR FAIL (ME) on display) signals an AC power disruption. The indicator lights whenever the battery supplies power to the electronic ventilator. If the battery is completely discharged, the AC power failure indicator does not have power and will not function.

Figure 2-14. AC Power Failure Indicator



### **Oxygen Supply Pressure Alarm**

The oxygen supply pressure alarm activates if the oxygen supply pressure in the system falls below about 37 psi. When the alarm is activated, the red O<sub>2</sub> SUPPLY PRESSURE indicator lights continuously, the LO O<sub>2</sub> SUPPLY message appears on the monitor, and an audible alarm sounds.

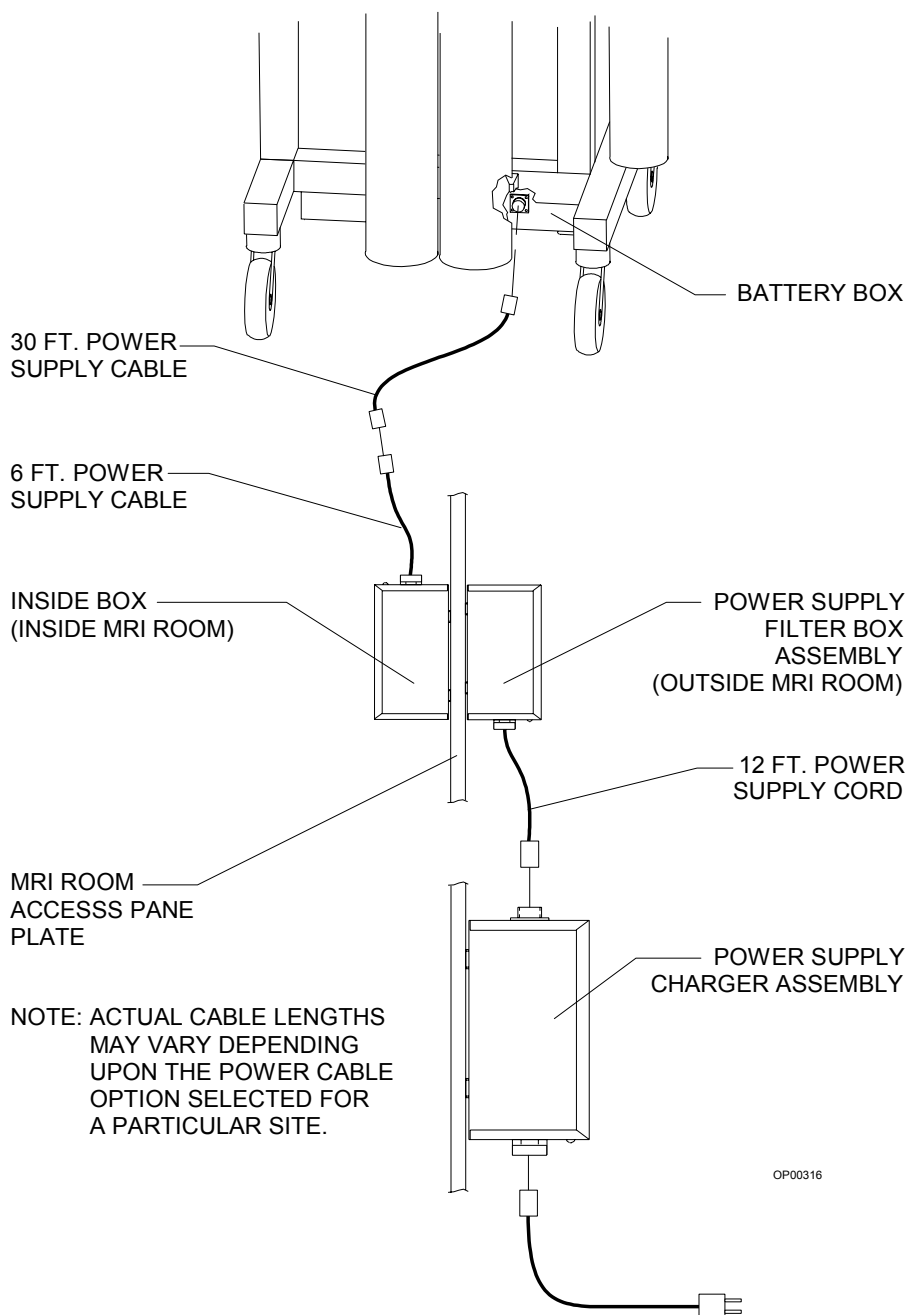
**NOTE:** The oxygen supply pressure alarm will not activate if only one source of oxygen supply pressure (either the cylinder or pipeline) fails and the other maintains proper supply pressure in the machine's oxygen supply lines.

### **Power Supply System**

The Narkomed MRI-2 is equipped with a battery backed-up power supply for the ventilator and alarm system. When in use, the Narkomed MRI-2 should be plugged into an AC outlet.

**WARNING:** The power supply charger assembly must not be taken into the magnet room. Damage to the equipment, MRI-2 system, or personal injury could result.

Figure 2-15. Power Supply System



## Battery System

The battery system consists of a rechargeable battery that powers the machine when the power supply charger assembly is inactive.

Although most hospitals have emergency generators that provide AC power when line power fails, a delay may occur before the generator power comes online. When the Narkomed MRI-2 is plugged into an AC outlet, the battery system automatically provides power during the period between a line power failure and activation of the hospital's emergency generator. The battery also provides power if the power cord is accidentally unplugged.

When the hospital's emergency generator comes online (or when a disconnected power cord is reconnected), the Narkomed MRI-2 automatically switches back to AC power and recharges its battery. The battery charging system charges the battery any time the power cord is connected to an active AC power source. The charger can recharge a fully discharged battery in about 16 hours with the Narkomed MRI-2 in the Standby mode.

## Machine Functions on Battery Power

When the battery system is used, the yellow AC POWER FAIL indicator on the alarm panel lights (the AC PWR FAIL (ME) monitor display message appears).

When the battery reserve approaches depletion, the yellow BATTERY LOW indicator lights (the BATTERY LOW (LO) monitor display message appears).

**NOTE:** When battery reserves are low, the BATTERY LOW indicator lights automatically during an AC power loss or when the BATTERY TEST button is pressed while AC power is applied.

The BATTERY LOW indicator signifies that 30 minutes or less of battery power remains from the time the alarm was activated. When the battery is depleted, the gas supply system remains operative. However, you must perform manual ventilation by bag, because power to the ventilator is cut off. The monitoring and alarm functions will not work until AC power is restored.

**NOTE:** If the power cord is not plugged into an active AC outlet for a period of 30 days or more, the battery may become depleted.

## Monitoring System

The anesthesia machine's monitoring system integrates the functions of the electronic monitors and organizes information from these monitors onto the screen, which is located on the front panel of the machine.

The Narkomed MRI-2 monitors the following measurements:

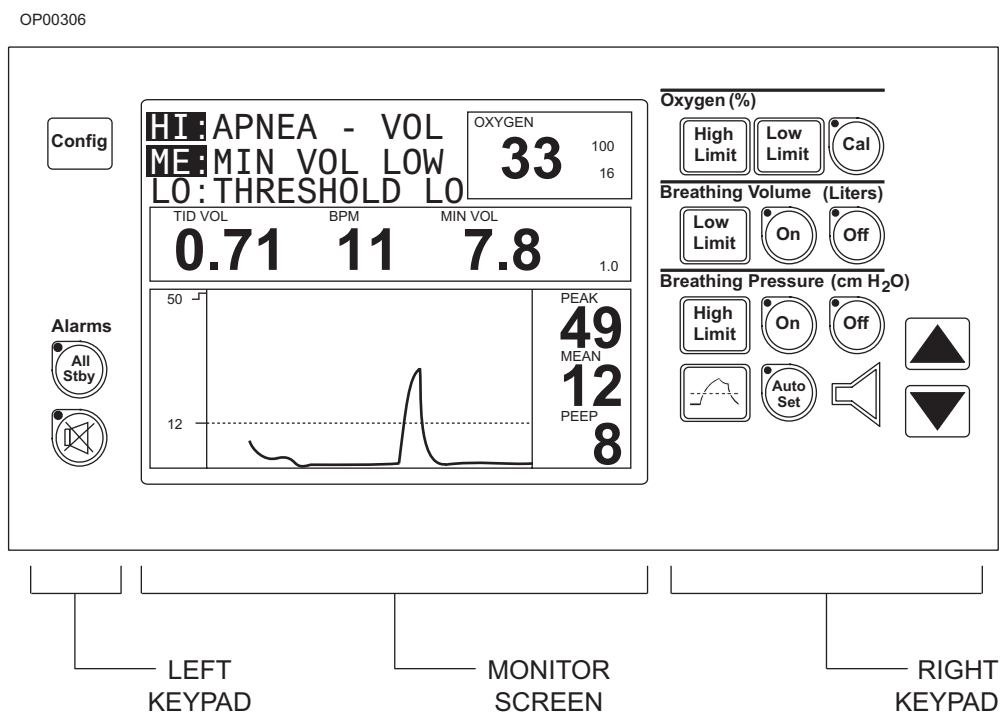
- oxygen concentration
- breathing pressure
- respiratory volume

The anesthesia machine also monitors key anesthesia system functions, such as oxygen supply pressure and backup battery status.

## Monitor Screen and Controls

All monitoring data and alarm messages are shown on the machine's monitor screen. The control keys on either side of the screen allow you to establish monitoring settings. With the left keypad, you can control system-wide settings, such as alarm annunciation and monitor configuration. With the right keypad, you can control settings for specific monitors: oxygen concentration, breathing pressure, and respiratory volume. See Figure 2-16 .

Figure 2-16. Monitor Screen and Controls



## Alarm System

Alarms are organized into three categories, depending on the urgency of the alarm condition.

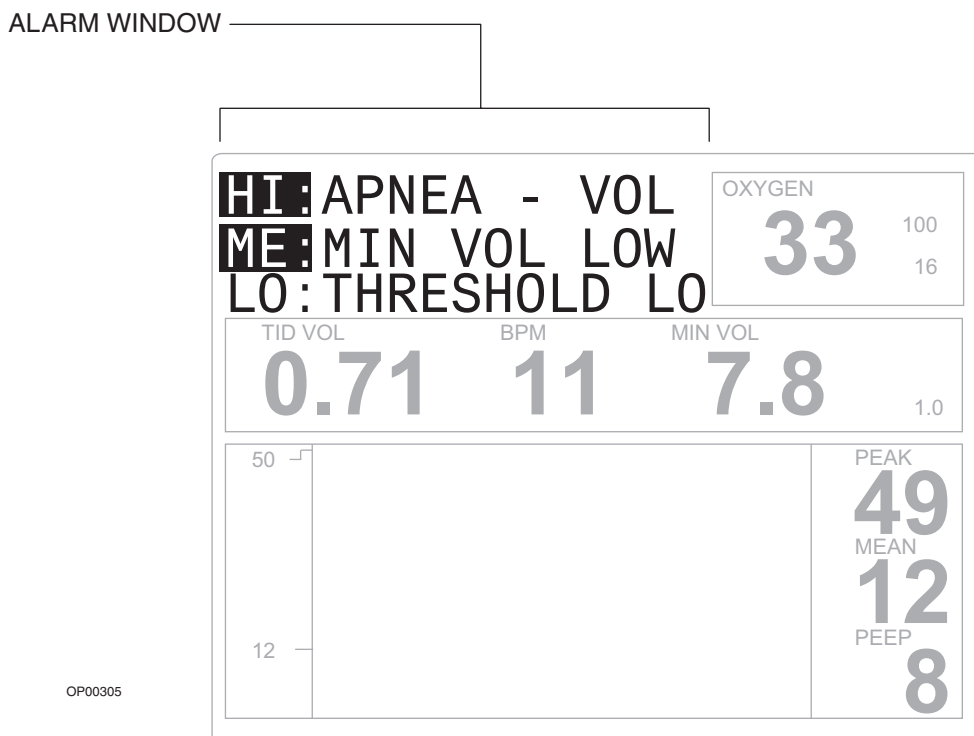
- **HI** - the highest priority alarms requiring an immediate response.
- **ME** - second priority alarms requiring a prompt response.
- **LO** - the lowest priority alarms requiring the operator's awareness

The Narkomed MRI-2 provides both visual and audible notification of the most urgent conditions.

## Alarm Display

The Narkomed MRI-2 presents messages for active alarm conditions in the Alarm window at the top of the monitor screen as shown in Figure 2-17 . Messages are displayed for up to three of the highest priority active alarm conditions. Any additional, lower priority active alarm conditions are retained in the monitor's memory. Messages for these lower priority conditions are displayed when the higher priority alarm conditions have been resolved and their messages have been removed from the display.

Figure 2-17. Alarm Display



**NOTE:** If a HI or ME message is removed from the Alarm window before you have a chance to read it, you can view the message in the Alarm Log. The Alarm Log is a separate screen that displays a sequential record of up to 100 of the most recent HI and ME messages. For more information, see “Using the Alarm Log” on page 10-8.

### Alarm Annunciation

Each alarm category is associated with a specific audible signal.

- **HI** - a five-pulse tone pattern that is initially repeated every few seconds until the alarm condition is resolved.
- **ME** - a three-pulse tone pattern that is repeated every 30 seconds.
- **LO** - a single tone or no sound at all, depending on the urgency of the alert.

Only the highest-priority, currently active alarm condition is annunciated. Tones for lower-priority alarm conditions are temporarily suppressed to minimize the confusion caused by simultaneous alarms.

### Ventilation Alarms

When the system power switch is turned from STANDBY to ON, the volume and pressure apnea alarms default to Standby to allow machine setup without nuisance alarms. An interlock with the ventilator ensures that when the ventilator is turned on, the alarms are enabled. You can also enable the alarms individually using the keypad.

When the ventilator is turned off, the following events occur:

- If the pressure apnea threshold was greater than 15 cm H<sub>2</sub>O when the ventilator was turned off, the threshold setting is changed to 15 cm H<sub>2</sub>O. (If the pressure apnea threshold was less than 15 cm H<sub>2</sub>O when the ventilator was turned off, the threshold retains its setting.)
- The ME and HI alarms associated with apnea alarms change from activation after 15 and 30 seconds of apnea to 30 and 60 seconds, respectively.

When the ventilator is turned back on, the pressure apnea threshold is restored to its previous set value and the apnea alarms revert to activation after 15 seconds (ME) and 30 seconds (HI) of apnea.

# 3

## Daily Checkout

*This section provides you with instructions detailing the steps for you to perform a daily checkout of the Narkomed MRI-2 anesthesia machine.*

Daily Checkout Procedure .....	3-2
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## Daily Checkout Procedure

Before operating the Narkomed MRI-2, perform the following checkout procedure to make sure the machine is ready for use. This is a recommended procedure. Follow your institution's policies regarding specific checkout procedures. If the anesthesia system fails any procedures identified by an asterisk (\*), do not use the machine. Contact an authorized representative of DrägerService to inspect the unit.

**WARNING:** Do not place any object on this machine unless it is specifically labeled to be used in an MRI scanning room and on the Narkomed MRI-2 anesthesia system. Objects placed on this machine that are not designed for use with this anesthesia system may be strongly attracted to the magnet and may cause serious injury or death when the machine is used in an MRI scanning room.

**NOTE:** Do not insert any additional components or modify the anesthesia system after the checkout procedure is started.

**NOTE:** When the peak breathing circuit pressure is reduced by more than approximately fifty (50) cmH<sub>2</sub>O, the apnea pressure alarm will become latched. Avoid producing this condition during the checkout procedures by keeping the maximum breathing circuit pressure below fifty (50) cmH<sub>2</sub>O while the monitor is energized or by bringing successive peak pressures down in twenty-five (25) cmH<sub>2</sub>O increments until the peak pressure is below fifty (50) cmH<sub>2</sub>O.

### Initial Setup and Verification

1. Enter the serial number located on the right rear leg into the anesthesia record.
2. Make sure there is a valid inspection sticker on the back of the machine, indicating that it was serviced and inspected by an authorized representative of DrägerService.
3. Verify that a cylinder wrench is tethered to the back of the machine next to the cylinder.
4. If the anesthesia machine is not already plugged in, connect the electrical power cable to an active AC outlet that accepts and properly grounds the power cable. **Do not** use “cheater” plugs. The term “cheater” plug implies any and all electrical plugs or other devices that can inhibit or prohibit the proper grounding of the anesthesia machine.

### Battery Power Verification

5. \* Turn the SYSTEM POWER switch to the ON position.
6. \* Wait for the monitor to complete its diagnostic checks.

7. \* Check the battery power. Press the BATTERY TEST button on the main switch panel. The green indicator must light. The yellow BATTERY LOW indicator must remain unlit.

**NOTE:** This test assumes the anesthesia machine has been plugged in for 16 hours. The battery charging system works only when the machine is plugged into an active AC power source. The charging system takes about 16 hours to charge a fully discharged battery.

### Emergency Ventilation Equipment

8. \* Verify that backup ventilation equipment is available and functional.

### High Pressure System Verification

9. \* Check the oxygen cylinder supplies.
  - a. Disconnect all pipeline gas supply hoses and drain the system.
  - b. Close the oxygen cylinder valve and remove the cylinder from the yoke. Verify that there is only one cylinder gasket and there are two index pins. Verify that the cylinder matches the yoke label. Replace the cylinder.
  - c. Open the oxygen cylinder and check the cylinder pressure gauge. A full oxygen cylinder registers a pressure of about 1900 psi. Replace any cylinder with pressure less than 1000 psi. To check for a high pressure leak, close the cylinder and observe the cylinder pressure gauge for a prominent decrease in the pressure. With the oxygen cylinder closed, press the oxygen flush button on the front of the anesthesia machine. Hold the button in until the pressure gauges indicate no pressure.
10. \* Check the nitrous oxide cylinder supplies.
  - a. Close the nitrous oxide cylinder valve and remove the cylinder from the yoke. Verify that there is only one cylinder gasket and two index pins. Verify that the cylinder matches the yoke label. Replace the cylinder on the yoke.
  - b. Open the nitrous oxide flow control valve until the nitrous oxide pipeline and cylinder pressure gauges indicate zero pressure. Open a nitrous oxide cylinder and check the cylinder pressure gauge. A full nitrous oxide cylinder registers a pressure of about 745 psi. Replace any cylinder with a pressure less than 600 psi. To check for a high pressure leak, close the cylinder and observe the cylinder pressure gauge for a prominent decrease in the pressure.

The following table shows the full and minimum pressures for E-size gas cylinders at 70° F, 21° C.

**WARNING:** Use only nonmagnetic (aluminum) E cylinders with this machine. Steel cylinders can cause serious injury or death if brought into an MRI scanning room.

**Table 3-1. Nitrous Oxide Cylinder PSI Levels**

<b>GAS</b>	<b>PSI - FULL*</b>	<b>PSI - MIN</b>
Nitrous Oxide	745	600
Oxygen	1900	1000

\* typical full load

**Pipeline  
Supply  
System  
Verification**

**11.\* Pipeline Supply Verification**

- a. Inspect the supply hoses for cracks or wear.
- b. Connect the appropriate hospital pipeline supply hoses from the wall outlet fittings to the pipeline inlet connectors.
- c. Check for a sufficient pipeline pressure on the pipeline pressure gauges located below the flow control valves. The pressure for each gas should be between 50–55 psi. Open the flow control valve for each gas to a moderate value. The pressure indicated at the pipeline pressure gauge must not decrease more than 5 psi.
- d. Verify that the correct gases are supplied to the anesthesia machine inlets.

**Low Pressure  
System  
Verification**

**12. \* Vaporizer Verification**

- a. Check for a sufficient supply of liquid anesthetic in the vaporizer using the vaporizer sight glass. The liquid level must be between the minimum and maximum markings.
- b. Make sure the vaporizer fill and drain valves are completely closed.
- c. Check the vaporizer exclusion system, which prevents more than one vaporizer from being activated simultaneously. Make sure that when one vaporizer handwheel is turned to a setting greater than “0”, the other remains locked in its “0” position. Test the system for both vaporizers. Then, turn all vaporizers to the “0” position.

**System Gas  
Circuit  
Verification**

13. \* Check the flowmeters. Adjust the flow control knob for each gas and verify the proper operation of the corresponding flowmeters. The float must move freely over the full range of each flowmeter.

**Oxygen  
Monitor  
Calibration**

14. \* Calibrate the oxygen monitor by exposing the sensor to ambient air and activate the calibration key. (See “Calibrating the Oxygen Sensor” on page 11-4 for more information.)

- a. Place the oxygen sensor securely in the sensor mount.
- b. Verify that the correct gas concentrations are supplied to the anesthesia system from the supply cylinder.
- c. Close the cylinder supplies and deplete the pressure from the system.

**OFPD  
Verification**

15. \* Check the oxygen failure protection device (OFPD). With all gases available on the machine set to a flow of about 4 l/min, discontinue the oxygen supply by disconnecting the oxygen pipeline supply hose and closing the oxygen cylinder. Check the flowmeters. The flow of all other gases must decrease proportionally to the decrease in oxygen flow and eventually shut off.

**ORC  
Verification**

16. \* Check the oxygen ratio controller (ORC). Open the nitrous oxide flow control valve to a flow of 10 l/min. Vary the oxygen flow with the oxygen flow control valve. The nitrous oxide flow indicated on the nitrous oxide flowmeter must automatically vary in response to the oxygen flow control valve adjustments.

The ORC must maintain a fresh gas oxygen/nitrous oxide flow ratio of at least 25 ±4% oxygen.

**NOTE:** When the nitrous oxide flow control valve is open and oxygen is flowing at a minimum rate (150-200 ml/min, nitrous oxide flows at about 500 ml/min.

**Oxygen  
Flush  
Verification**

17. \* Check the oxygen flush:
  - a. Press the oxygen flush button. Listen for an audible gas flow sound, accompanied by a marked increase in oxygen concentration in the breathing system.
  - b. Check the delivered oxygen concentration. Repeatedly flush the patient breathing system by pressing the oxygen flush button. Open the oxygen flow control valve to 8 l/min flow and close the other flow control valves. The oxygen measurement display area should indicate 97% to 100% oxygen concentration.

**Fresh Gas  
Verification**

18. \* Make sure the vaporizers are closed. Open the oxygen flow control valve to an 8 l/min flow and close all other flow control valves. Sniff the gas coming from the fresh gas common outlet. There should be no noticeable odor.

**Bain Circuit  
Adapter  
Verification**

19. \* Verify that the inner tube of the Bain circuit is intact and not occluded. First deliver a flow of oxygen to the Bain circuit through the fresh gas hose. Then occlude the inner tube of the Bain circuit. The oxygen flowmeter float should drop in response to the occlusion.

As an alternate test, press the oxygen flush button with the Bain circuit's patient port open to the atmosphere. The high flow of gas through the Bain circuit's inner tube will draw in gas from the outer tube. As a result, the breathing bag should deflate. If the breathing bag does not deflate or it inflates, the fresh gas hose or inner tube may be improperly connected.

### Absorber System Verification

20. \* To check the absorber system:
  - a. Check the hose connections in the breathing system.
  - b. Make sure the fresh gas hose of the breathing system is securely connected to the fresh gas outlet.
  - c. Make sure a 22 mm patient breathing circuit is connected between the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor.
  - d. Make sure a 22 mm breathing hose is connected between the ventilator hose terminal and the manual/automatic selector valve breathing hose terminal.
  - e. Make sure a breathing bag of proper capacity and appropriate construction is connected to the breathing bag terminal of the breathing system.
  - f. Make sure the breathing pressure pilot line is properly connected between the BREATHING PRESSURE interface and either the absorber quick-connect fitting or the appropriate fitting at or near the patient Y-piece.
  - g. Make sure the oxygen sensor and flow sensor are properly installed.
21. \* Make sure the absorber canisters are filled with CO<sub>2</sub> absorbent and that the absorbent is useable. Consult the absorbent manufacturer's literature for information about what signs to expect when the absorbent is exhausted. Replace the absorbent when it appears exhausted. Make sure that the color change represents the absorbent's true state of depletion and is not due to regeneration after a rest period. Flushing the anesthesia machine continuously with 100% oxygen for at least one minute before the first case of the day is recommended.

Remove accumulated absorbent dust and water from the absorber dust cup.

**WARNING:** Absorbent is caustic and is a strong eye, skin, and respiratory tract irritant. When emptying the absorber dust cup, take care not to spill its caustic contents.

**NOTE:** When changing the CO<sub>2</sub> absorbent, take care not to chip or crack the absorbent canister. Check the canister for signs of damage, especially along the rim, before reinstallation.

22. Close all vaporizers and gas flow sources. Check for free gas passage in the patient breathing system. Wear a surgical mask to inhale and exhale through the breathing system (each limb individually, if possible). Verify the unidirectional flow in each limb and then reconnect the tubing.

#### **APL Valve Verification**

23. \* Check the adjustable pressure limiter (APL) valve, which functions as the patient system relief valve. The APL valve must be capable of relieving excess gas from the breathing system into the scavenger system.

To check the APL valve's flow resistance:

- a. Set the manual/automatic selector valve to BAG.
- b. Remove the bag from the swivel arm bag mount.
- c. Interconnect the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm hose.
- d. Completely open the APL valve by turning the control knob fully counterclockwise to its stop position.
- e. Turn the SYSTEM POWER switch to ON.
- f. Open the oxygen flow control valve to a flow of 8 l/min.
- g. Occlude the bag mount opening and watch for a pressure increase on the breathing system pressure gauge. This pressure increase must not exceed 3 cmH<sub>2</sub>O.

#### **Breathing System Leak Test**

24. Perform a breathing and fresh gas delivery system pressure test. This test detects leaks from the patient breathing system and fresh gas delivery system.

To perform the test:

- a. Close all flow control valves on the anesthesia machine.
- b. Turn the SYSTEM POWER switch to the STANDBY position.
- c. Turn the vaporizer to 0% concentration.
- d. Interconnect the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm breathing hose.
- e. Set the manual/automatic selector valve to BAG.
- f. Close the APL valve by turning the knob fully clockwise to its stop position.

- g. Check that the breathing pressure gauge is on 0.
- h. Attach the supplied test terminal to the breathing bag mount.
- i. Connect a sphygmomanometer squeeze bulb (available from Draeger Medical) to the hose barb on the test terminal.
- j. Pump the squeeze bulb by hand until the breathing system pressure gauge indicates pressure of at least 50 cmH<sub>2</sub>O (not to exceed 80 cmH<sub>2</sub>O).
- k. Observe the pressure drop at the breathing system pressure gauge. When the pressure is at 50 cmH<sub>2</sub>O, begin counting seconds. The pressure must not drop more than 20 cmH<sub>2</sub>O in 30 seconds.

### Scavenger System Verification

#### 25. \* Verify the performance of the scavenger system.

To test the open reservoir scavenger system:

- a. Make sure a 19 mm scavenger hose is connected between the ventilator relief valve and the scavenger interface.
- b. Make sure a 19 mm scavenger hose is connected between the APL valve on the absorber and the 19 mm hose terminal on the rear of the absorber pole.
- c. Make sure a 19 mm scavenger hose is connected between the bottom of the absorber pole and the scavenger interface.
- d. Check for moisture accumulation in the breathing and scavenger hoses. Remove any moisture found.
- e. Verify the safe performance of the open reservoir scavenger system. With the scavenger system properly installed and operating, test for positive and negative pressure relief.

To test for negative pressure relief:

- f. Connect a vacuum hose to the DISS threaded terminal on the left-hand side of the scavenger (or attach a wall suction hose onto the adapter's hose-barb fitting).
- g. Short-circuit the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm breathing hose.
- h. Set the absorber's manual/automatic selector valve to BAG.
- i. Turn the APL valve control knob fully counterclockwise.
- j. Verify that the suction waste gas disposal system is active.
- k. Adjust the scavenger needle valve to a flowmeter indication between the two white lines.
- l. Close all flow control valves on the anesthesia system.

- m. Occlude the absorber breathing bag terminal and observe the breathing pressure gauge on the absorber. The gauge should indicate only a negligible negative pressure (no lower than -0.5 cmH<sub>2</sub>O).

To test for positive pressure relief:

- n. Perform steps A through E.
- o. Adjust the scavenger needle valve to a completely closed position by turning it fully clockwise.
- p. Open the oxygen flow control valve to a flow of 10 l/min and occlude the absorber breathing bag terminal.
- q. The flow of oxygen must now exit through the relief ports located on top of the canister. The absorber system's breathing pressure gauge must indicate a pressure less than 5 cmH<sub>2</sub>O.
- r. After the test, adjust the scavenger needle valve to a flowmeter indication halfway between the two white lines.

To test the scavenger interface for passive systems:

- s. Make sure a 19 mm scavenger hose is connected between the ventilator relief valve and the scavenger interface.
- t. Make sure a 19 mm scavenger hose is connected between the APL valve on the absorber and the 19 mm hose terminal on the back of the absorber pole.
- u. Make sure a 19 mm scavenger hose is connected between the bottom of the absorber pole and the scavenger interface.
- v. Check for moisture accumulation in the breathing and scavenger hoses. Remove any moisture found.
- w. Short-circuit the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm breathing hose.
- x. Set the absorber's manual/automatic selector valve to AUTO.
- y. Open the oxygen flow control valve to a flow of 10 l/min and occlude the 19 mm scavenger terminal labeled EXHAUST.
- z. After the ventilator bellows inflates, the flow of oxygen exits the system through the positive pressure safety relief valve. At this point, the absorber system's breathing pressure gauge must indicate a pressure of less than 10 cmH<sub>2</sub>O.

## Tracheal Suction System

For checkout procedures for the tracheal suction system, see the manufacturer's instructions supplied with the suction system assembly.

### Manual and Automatic Ventilation Systems

26. \* Check for proper pressure and flow at the Y-piece during the inspiratory and expiratory phases. Turn the SYSTEM POWER switch and ventilator power switch to their ON positions. Place the manual/automatic selector valve in the AUTO position. Adjust the oxygen flow control valve to a 3 l/min flow. Set the ventilator frequency to 3 BPM, the I:E ratio to 1:2, and the tidal volume to about 1 liter.

Adjust the ventilator flow control to the maximum of the “low” zone on the flow gauge. Occlude the patient side of the Y-piece. Fill the ventilator bellows by pressing the oxygen flush button. Observe the breathing system pressure gauge as the ventilator cycles.

The pressure gauge must indicate a pressure over 30 cmH<sub>2</sub>O when the bellows completes its downward travel. The pressure should not exceed 3 cmH<sub>2</sub>O at the end of the expiratory phase, when the bellows completes its upward travel.

### Monitor

27. Check the alarm limit settings. The monitor alarm limits are automatically set to a default configuration when the SYSTEM POWER switch is turned on. Check these settings and adjust them if necessary. Alarm limits can be adjusted at the beginning of or during a procedure. Also, make sure that any external monitors (if any) are connected properly.
28. \* Test the alarm functions. Simulate alarm conditions and check for appropriate alarm signals.

### System Flush

29. Flush the system for at least one minute with 100% oxygen by pressing the oxygen flush button.

### Final Position

30. When the end of the daily checkout procedure is complete, verify that:
- a. vaporizers are off (handwheels set to 0)
  - b. the APL valve is open (fully counterclockwise)
  - c. the manual/automatic switch is set to BAG
  - d. all flowmeters indicate 0 (or minimum)
  - e. the patient suction level is adequate
  - f. the breathing system is ready to use with the bag in place and all hoses connected properly.

**WARNING:** Always lock the casters after this anesthesia machine has been positioned in the MRI scanner room. Magnetic attractive forces between the magnet and the anesthesia machine may cause unintentional movement of the anesthesia machine if the casters are unlocked.

# 4

## Preuse Checkout

*This section provides you with instructions detailing the steps for you to perform a preuse checkout of the Narkomed MRI-2 anesthesia machine.*

Preuse Checkout Procedure .....	4-2
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## Preuse Checkout Procedure

Perform the following abbreviated checkout procedure when the Narkomed MRI-2 is used in successive cases. It may be performed only after the initial daily checkout procedure given in Section 3 is performed. This is a recommended procedure only. Follow your institution's policies regarding specific checkout procedures. If the anesthesia system fails any procedures identified by an asterisk (\*), do not use the machine. Contact an authorized representative of DrägerService to inspect the unit.

**NOTE:** Do not insert any additional components into, or modify, the anesthesia system after the checkout procedure is started.

### Battery Power Verification

1. \* Turn the SYSTEM POWER switch to the ON position.
2. \* Wait for the monitor to complete its diagnostic checks.
3. \* Check the battery power. Press the BATTERY TEST button on the main switch panel. The green indicator must light. The yellow BATTERY LOW indicator must remain unlit.

**NOTE:** This test assumes the anesthesia machine has been plugged in for 16 hours. The battery charging system works only when the machine is plugged into an active AC power source. The charging system takes about 16 hours to charge a fully discharged battery.

### Bain Circuit Adapter Verification

4. \* Verify that the inner tube of the Bain circuit is intact and not occluded. First deliver a flow of oxygen to the Bain circuit through the fresh gas hose. Then occlude the inner tube of the Bain circuit. The oxygen flowmeter float should drop in response to the occlusion.

As an alternate test, press the oxygen flush button with the Bain circuit's patient port open to the atmosphere. The high flow of gas through the Bain circuit's inner tube will draw in gas from the outer tube. As a result, the breathing bag should deflate. If the breathing bag does not deflate or it inflates, the fresh gas hose or inner tube may be improperly connected.

### Absorber System Verification

5. \* To check the absorber system:
  - a. Check the hose connections in the breathing system.
  - b. Make sure the fresh gas hose of the breathing system is connected securely to the fresh gas outlet.
  - c. Make sure a 22 mm patient breathing circuit is connected between the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor.

- d. Make sure a 22 mm breathing hose is connected between the ventilator hose terminal and the manual/automatic selector valve breathing hose terminal.
  - e. Make sure a breathing bag of proper capacity and appropriate construction is connected to the breathing bag terminal of the breathing system.
  - f. Make sure the breathing pressure pilot line is properly connected between the BREATHING PRESSURE interface and either the absorber quick-connect fitting or the appropriate fitting at or near the patient Y-piece.
  - g. Make sure the oxygen sensor and flow sensor are properly installed.
6. \* Make sure the absorber canister is filled with CO<sub>2</sub> absorbent. Consult the absorbent manufacturer's literature for what signs to expect when the absorbent is exhausted. Replace the absorbent when it appears exhausted. Make sure that the color change represents the absorbent's true state of depletion and is not due to regeneration after a rest period. Flushing the anesthesia machine continuously with 100% oxygen for at least one minute before the first case of the day is recommended.

Remove accumulated absorbent dust and water from the absorber dust cup.

**WARNING:** Absorbent is caustic and is a strong eye, skin, and respiratory tract irritant. When emptying the absorber dust cup, take care not to spill its caustic contents.

**NOTE:** When changing the CO<sub>2</sub> absorbent, take care not to chip or crack the absorbent canister. Check the canister for signs of damage, especially around the rim, before reinstallation.

7. Close the vaporizer and flow control valves. Check for free gas passage in the patient breathing system. With a surgical mask over your mouth, inhale and exhale through the breathing system (each limb individually, if possible). Verify the unidirectional flow in each limb and then reconnect the tubing.

## APL Valve

8. \* Check the APL valve to be sure it can relieve excess gas from the breathing system into the scavenger system.

To check the APL valve's flow resistance:

- a. Ensure that the ventilator on/off switch is in the "off" position; the autobag selector switch does not control the ventilator on the Narkomed MRI-2.
- b. Set the manual/automatic selector valve to BAG.

- c. Remove the bag from the swivel arm bag mount.
- d. Interconnect the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm hose.
- e. Completely open the APL valve by turning the control knob fully counterclockwise to its stop position.
- f. Turn the SYSTEM POWER switch to ON.
- g. Open the oxygen flow control valve to a flow of 8 l/min.
- h. Occlude the bag mount opening and watch for a pressure increase on the breathing system pressure gauge. This pressure increase must not exceed 3 cmH<sub>2</sub>O.

#### **Breathing System Leak Test**

9. Perform a breathing and fresh gas delivery system pressure test. This test detects leaks from the patient breathing system and fresh gas delivery system.

To perform the test:

- a. Close all flow control valves on the anesthesia machine.
- b. Turn the SYSTEM POWER switch to the STANDBY position.
- c. Turn the vaporizer to 0% concentration.
- d. Interconnect the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm breathing hose.
- e. Set the manual/automatic selector valve to BAG.
- f. Close the APL valve by turning the knob fully clockwise to its stop position.
- g. Check that the breathing pressure gauge is on 0.
- h. Attach the supplied test terminal to the breathing bag mount.
- i. Connect a sphygmomanometer squeeze bulb (available from Draeger Medical) to the hose barb on the test terminal.
- j. Pump the squeeze bulb by hand until the breathing system pressure gauge indicates pressure of at least 50 cmH<sub>2</sub>O (not to exceed 80 cmH<sub>2</sub>O).
- k. Observe the pressure drop at the breathing system pressure gauge. When the pressure is at 50 cmH<sub>2</sub>O, begin counting seconds. Thirty seconds or longer are needed for a pressure drop from 50 to 30 cmH<sub>2</sub>O.

## Scavenger System

### 10. \* Verify the performance of the scavenger system.

To test the open reservoir scavenger system:

- a. Make sure a 19 mm scavenger hose is connected between the ventilator relief valve and the scavenger interface.
- b. Make sure a 19 mm scavenger hose is connected between the APL valve on the absorber and the 19 mm hose terminal on the back of the absorber pole.
- c. Make sure a 19 mm scavenger hose is connected between the bottom of the absorber pole and the scavenger interface.
- d. Check for moisture accumulation in the breathing and scavenger hoses. Remove any moisture found.
- e. Verify the safe performance of the open reservoir scavenger system. With the scavenger system properly installed and operating, test for positive and negative pressure relief.

To test for negative pressure relief:

- f. Connect a vacuum hose to the DISS threaded terminal on the left-hand side of the scavenger (or attach a wall suction hose onto the adapter's hose-barb fitting).
- g. Short-circuit the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm breathing hose.
- h. Set the absorber's manual/automatic selector valve to BAG.
- i. Turn the APL valve control knob fully counterclockwise.
- j. Verify that the suction waste gas disposal system is active.
- k. Adjust the scavenger needle valve to a flowmeter indication between the two white lines.
- l. Close all flow control valves on the anesthesia system.
- m. Occlude the absorber breathing bag terminal and observe the breathing pressure gauge on the absorber. The gauge should indicate only a negligible negative pressure (no lower than -0.5 cmH<sub>2</sub>O).

To test for positive pressure relief:

- n. Perform steps A through E.
- o. Adjust the scavenger needle valve to a completely closed position by turning it fully clockwise.
- p. Open the oxygen flow control valve to a flow of 10 l/min and occlude the absorber breathing bag terminal.

- q. The flow of oxygen must now exit through the relief ports located on top of the canister. The absorber system's breathing pressure gauge must indicate a pressure less than 5 cmH<sub>2</sub>O.
  - r. After the test, adjust the scavenger needle valve to a flowmeter indication halfway between the two white lines.
- To test the scavenger interface for a passive systems:
- s. Make sure a 19 mm scavenger hose is connected between the ventilator relief valve and the scavenger interface.
  - t. Make sure a 19 mm scavenger hose is connected between the APL valve on the absorber and the 19 mm hose terminal on the back of the absorber pole.
  - u. Make sure a 19 mm scavenger hose is connected between the bottom of the absorber pole and the scavenger interface.
  - v. Check for moisture accumulation in the breathing and scavenger hoses. Remove any moisture found.
  - w. Short circuit the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor with a 22 mm breathing hose.
  - x. Set the absorber's manual/automatic selector valve to AUTO.
  - y. Open the oxygen flow control valve to a flow of 10 l/min and occlude the 19 mm scavenger terminal labeled EXHAUST.
  - z. After the ventilator bellows inflates, the flow of oxygen exits the system through the positive pressure safety relief valve. At this point, the absorber system's breathing pressure gauge must indicate a pressure of less than 10 cmH<sub>2</sub>O.

#### Manual and Automatic Ventilation Systems

11. \* Check for proper pressure and flow at the Y-piece during the inspiratory and expiratory phases. Turn the SYSTEM POWER switch and ventilator power switch to their ON positions. Place the manual/automatic selector valve in the AUTO position. Adjust the oxygen flow control valve to a 3 l/min flow. Set the ventilator frequency to 3 BPM, the I:E ratio to 1:2, and the tidal volume to about 1 liter.

Adjust the ventilator flow control to the maximum of the "low" zone on the flow gauge. Occlude the patient side of the Y-piece. Fill the ventilator bellows by pressing the oxygen flush button. Observe the breathing system pressure gauge as the ventilator cycles.

The pressure gauge must indicate a pressure over 30 cmH<sub>2</sub>O when the bellows completes its downward travel. At the end of the expiratory phase, when the bellows completes its upward travel, the pressure should not exceed 3 cmH<sub>2</sub>O.

**Monitor**

12. Check the alarm limit settings. The monitor alarm limits are automatically set to a default configuration when the SYSTEM POWER switch is turned on. Check these settings and adjust them if necessary. Alarm limits can be adjusted at the beginning of or during a procedure. Also, make sure that any external monitors (if any) are connected properly.
13. \* Test the alarm functions. Simulate alarm conditions and check for appropriate alarm signals.

**System Flush**

14. Flush the system with 100% oxygen by pressing the oxygen flush button.

**Final Position**

15. At the end of the checkout procedure, verify that the final status of the machine is as follows:
  - a. vaporizers are off (handwheels set to 0)
  - b. the APL valve is open (fully counterclockwise)
  - c. Ensure that the ventilator on/off switch is in the "off" position; the autobag selector switch does not control the ventilator on the Narkomed MRI-2.
  - d. the manual/automatic switch is set to BAG
  - e. all flowmeters are indicating 0 (or minimum)
  - f. the patient suction level is adequate
  - g. the breathing system is ready to use (bag in place and all hoses connected properly).

**WARNING:** Always lock the casters after this anesthesia machine has been positioned near the MRI scanner magnet. Magnetic attractive forces between the magnet and the anesthesia machine may cause unintentional movement of the anesthesia machine if the casters are unlocked.

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# 5

## Gas Delivery System Operation

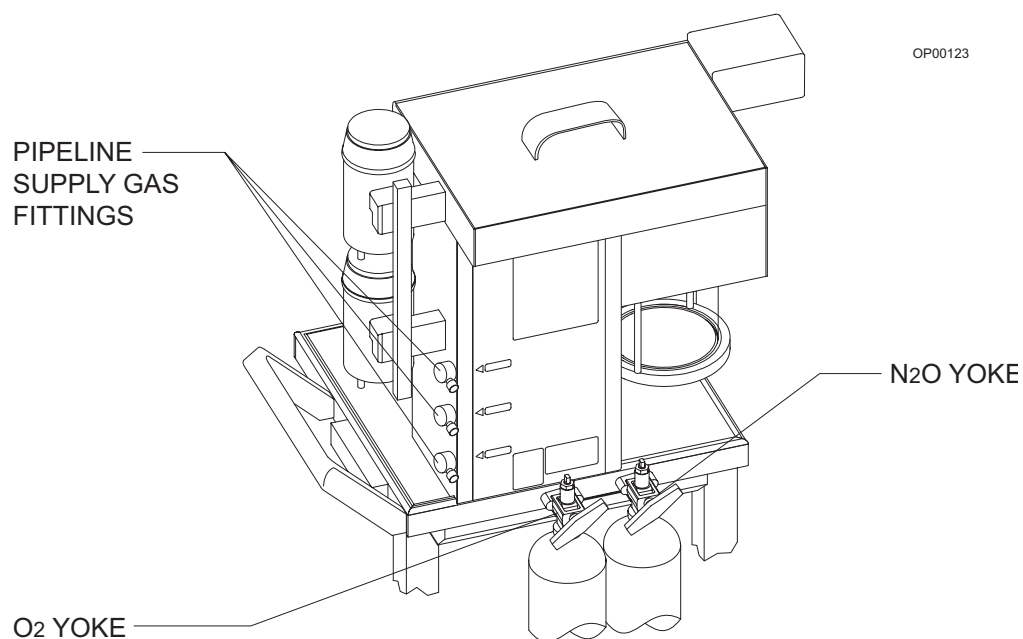
*This section provides you with a description of the Gas Delivery System of the Narkomed MRI-2 anesthesia machine.*

Overview .....	5-2
Connecting the Pipeline Gas Supply .....	5-3
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## Overview

The Narkomed MRI-2 is a continuous flow anesthesia system with pneumatic circuitry for mixing and delivering gases and anesthetic agent vapor. The pneumatic system can deliver up to three gases and one anesthetic agent simultaneously. Oxygen, air, and nitrous oxide are standard. In addition, two vaporizers can be mounted on the machine. Vaporizers are available for halothane, enflurane, isoflurane, and sevoflurane.

Figure 5-1. Gas Fittings and Yokes



## Connecting the Pipeline Gas Supply

Gas from the hospital pipelines enters the anesthesia machine through hoses connected to indexed inlets located on the side of the flowmeter housing. Depending on the country's standards and regulations, the available inlets are Diameter-Indexed Safety System (DISS) inlets (body or nut fitting) or National Institute for Standards and Technology (NIST) inlets.

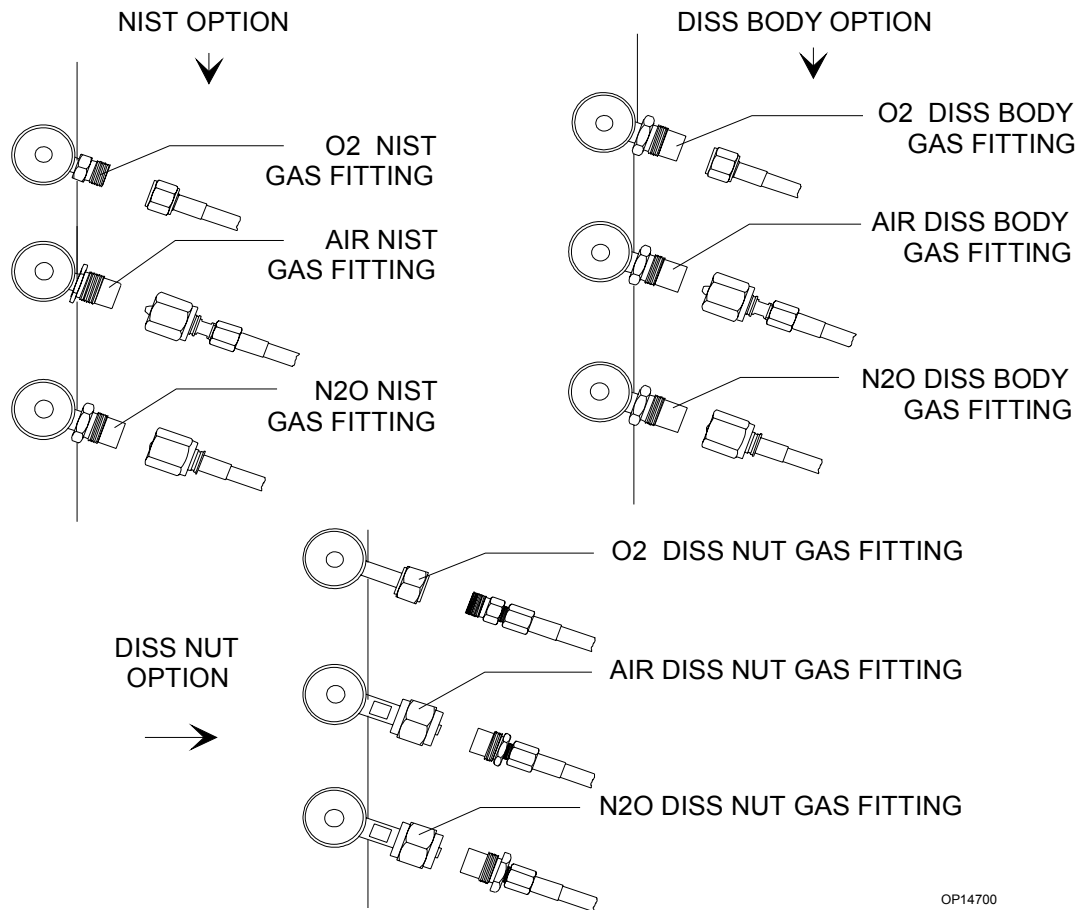
To connect a pipeline supply:

1. Connect the gas fitting on the supply hose to the corresponding gas fitting on the side of the flowmeter housing. Use a wrench to tighten the hex nut.

**WARNING:** Carefully check hoses each time you connect the machine to a wall or ceiling outlet to ensure that both ends of the hose are indexed for the same gas. Pipeline delivery hoses used between wall outlets and anesthesia machines have caused accidents when an oxygen fitting was placed on one end of the hose and a nitrous oxide fitting on the other end.

2. Connect the other end of the supply hose to the appropriate functioning hospital pipeline supplies.
3. Check the pipeline pressure gauge located on the front panel for sufficient pipeline pressure (50-55 psi).

Figure 5-2. Connecting the Pipeline Gas Supply



OP14700

## Connecting the Gas Cylinder

When attaching a cylinder, make sure that only one washer is installed between the cylinder and the yoke gas inlet. Using multiple washers may compromise the pin-indexed safety system. Be sure to verify the integrity of both index pins when installing a new cylinder.

**WARNING:** Use only nonmagnetic (aluminum) E-cylinders with this machine. Steel cylinders can cause serious injury or death if brought into an MRI scanning room.

To connect a gas cylinder to its yoke:

1. Place a new washer on the seat of the yoke gas inlet connection.

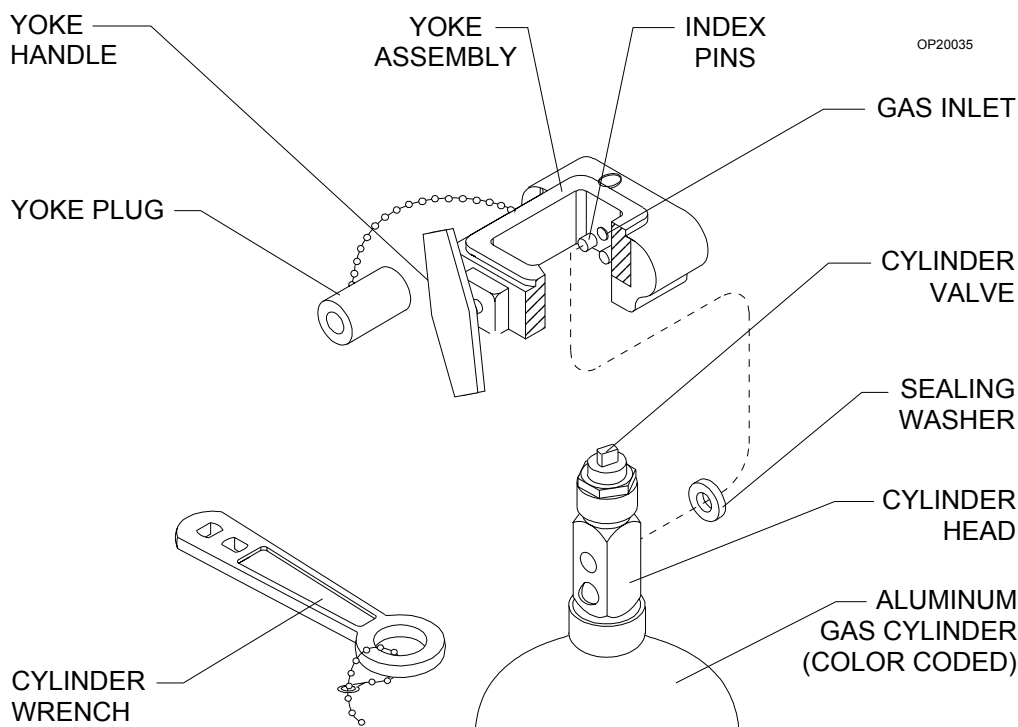
**WARNING:** Use only one cylinder washer for each yoke. Using more than one washer could cause cylinder gas leakage and compromise the pin-indexing system.

2. Verify that the two index pins below the gas inlet are intact.

**WARNING:** Check cylinder yokes for the integrity of the two index pins each time you attach a cylinder to the machine.

3. Insert the head of a gas cylinder with matching gas into the yoke from below. The gas outlet and index holes on the cylinder head must face the gas inlet and index pins on the yoke assembly.
4. Fit the index pins with the index holes. Screw the yoke handle clockwise against the cylinder head until the point of the yoke handle bolt aligns with the recess on the back of the cylinder head.
5. Verify that the sealing washer is in place, that the index pins are engaged, and that the cylinder hangs vertically. Tighten the yoke handle securely.

Figure 5-3. Connecting the Gas Cylinder



## Connecting the Fresh Gas Hose

To connect the fresh gas hose, pull out the fresh gas locking bar located on the front of the machine to its extended position. Insert the 15 mm male fitting on the fresh gas hose into the 15 mm female terminal. Release the spring-loaded locking bar over the fitting, allowing it to “lock” the fitting into place.

**WARNING:** Do not pinch or kink the fresh gas hose leading from the fresh gas outlet to the absorber.

## Adjusting the Gas Flow

To adjust the gas flow:

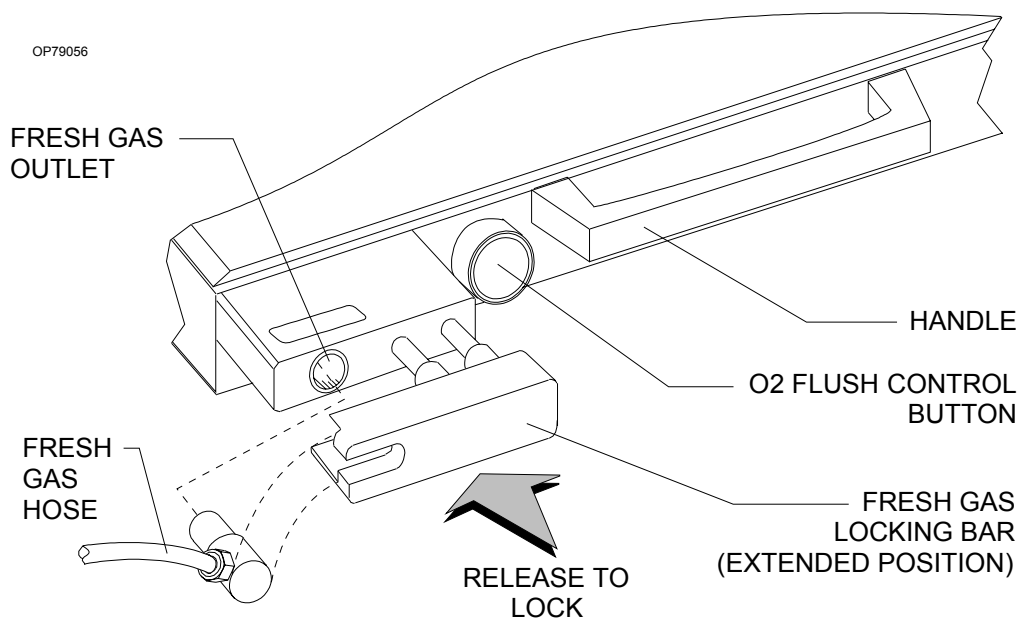
1. Turn the flow control knob located below the flowmeter tube for the preferred gas. Turning the valve knob counterclockwise increases flow. Turning the knob clockwise decreases flow.
2. While adjusting the flow control knob, observe the flow rate. Flow rate is indicated by the flowmeter scale reading at the center of the float.

**CAUTION:** The flow of oxygen cannot be completely shut off (see “Minimum Oxygen Flow” on page 2-7). Do not force the oxygen flow control knob past the zero-stop to shut off the minimum flow. Forcing the knob can damage the valve seat.

## Using the Oxygen Flush

To use the oxygen flush, press the oxygen flush button located on the front of the machine for a few seconds. This introduces an unmetered flow of pure oxygen into the breathing circuit at a rate of about 55 l/min.

Figure 5-4. Using the Oxygen Flush



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# 6

## Open Reservoir Scavenger Operation

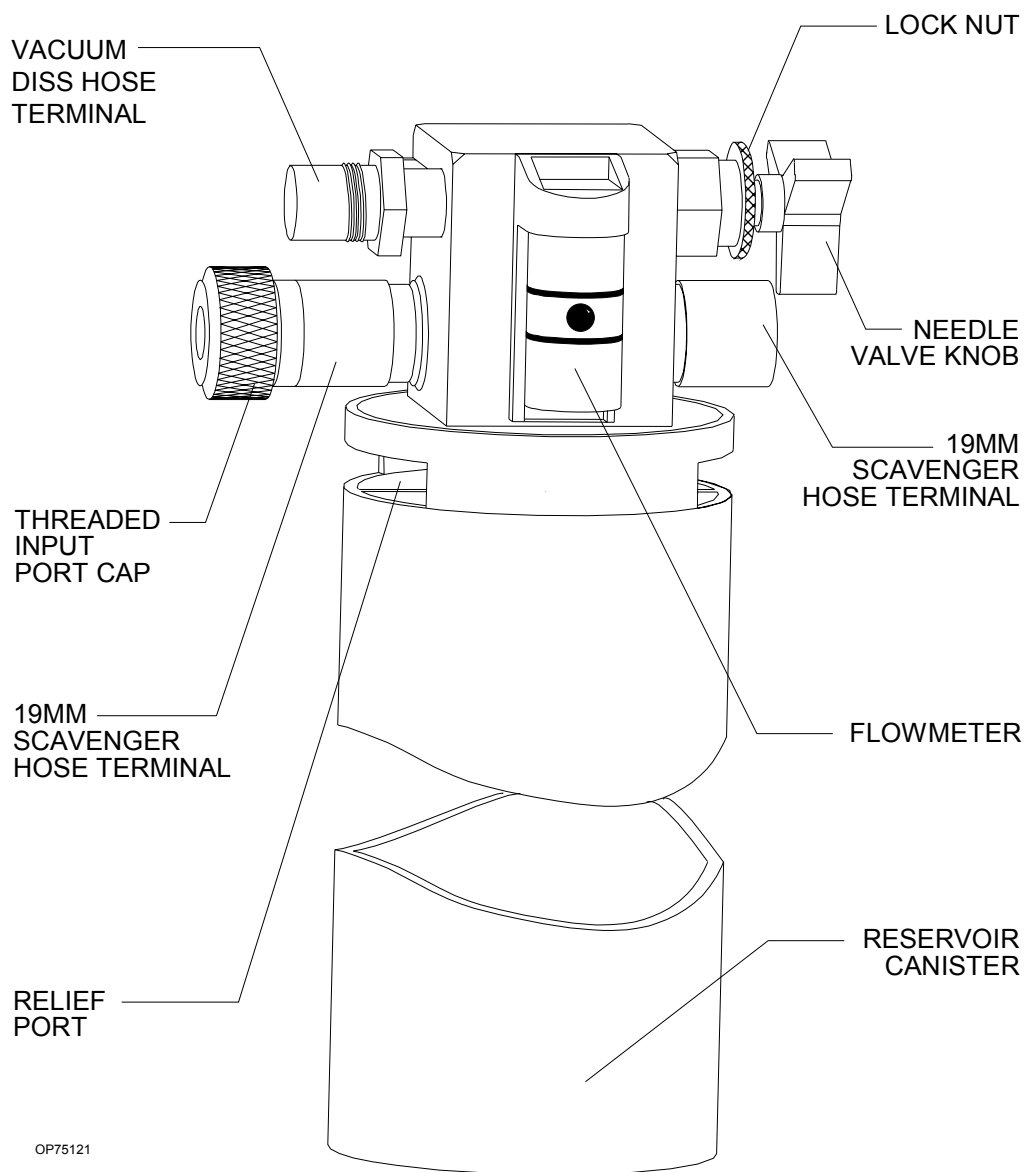
*This section describes the open reservoir scavenger used in the Narkomed MRI-2 anesthesia machine.*

Overview .....	6-2
Connecting the Open Reservoir Scavenger System .....	6-3
Operating the Open Reservoir Scavenger System .....	6-4

## Overview

The open reservoir scavenger is intended for use with suction (vacuum) waste gas disposal systems. This scavenging approach applies a continuous suction to transfer waste gas from the scavenger to the disposal system. The open reservoir scavenger is an “open” system, which uses continually open relief ports to provide positive and negative pressure relief.

Figure 6-1. Open Reservoir Scavenger



## Connecting the Open Reservoir Scavenger System

The open reservoir scavenger system is installed on the Narkomed MRI-2 before shipping. However, the hoses must be connected before operation.

**CAUTION:** Take special care not to accidentally force 19 mm scavenger hoses over 22 mm breathing hose terminals. Carefully follow the hose connection instructions for installing the scavenger and the absorber.

To connect the scavenger hoses:

1. Attach a 19 mm scavenger hose between the 19 mm terminal (marked SCAVENGER HOSE) on the bottom of the absorber pole and the 19 mm terminal (marked SCAVENGER HOSE) on the right side of the scavenger.

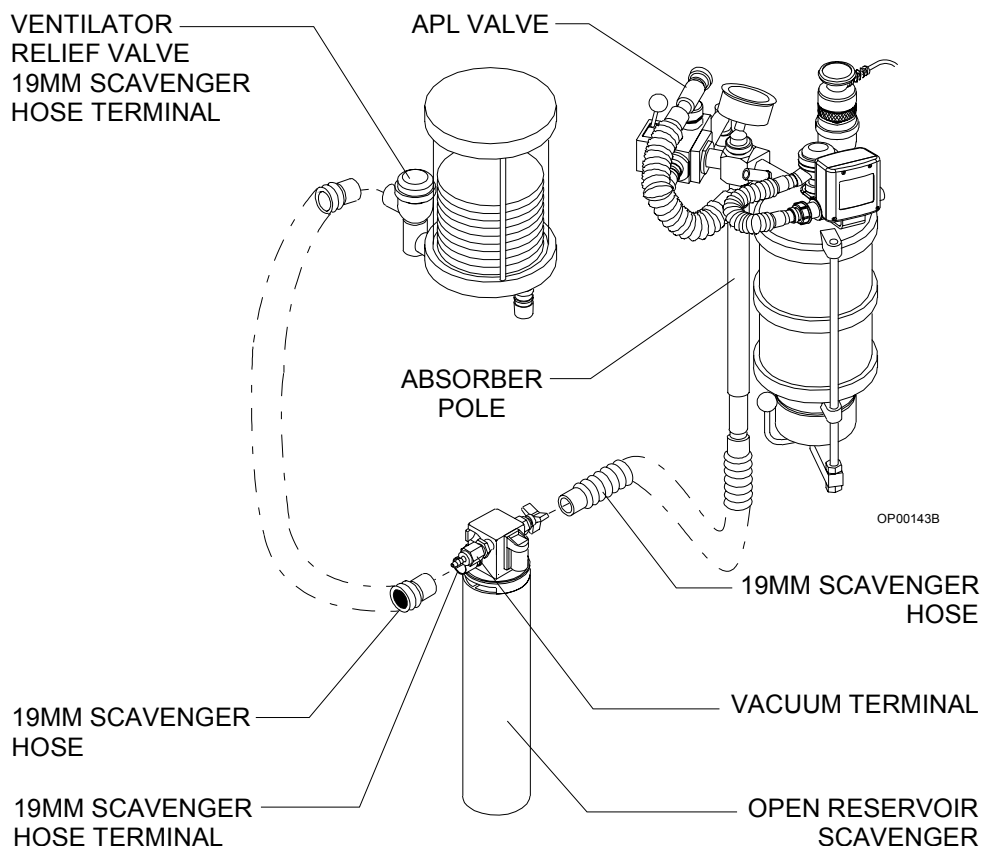
**WARNING:** Make sure the 19 mm scavenger hoses leading from the absorber are not pinched, kinked, or blocked in any manner.

2. Attach the short 19 mm scavenger hose between the 19 mm terminal (marked SCAVENGER HOSE) on the rear of the APL valve and the 19 mm terminal (marked SCAVENGER HOSE) on the rear of the absorber pole.
3. Attach another 19 mm scavenger hose between the 19 mm terminal (marked SCAVENGER HOSE) on the ventilator relief valve and the 19 mm terminal (marked SCAVENGER HOSE) on the left-hand side of the scavenger.

**WARNING:** Make sure the 19 mm scavenger hose leading from the ventilator relief valve is not pinched, kinked, or blocked in any manner.

4. Attach a wall suction hose between the wall suction outlet and the suction terminal (DISS or hose barb with adapter) on the scavenger.
5. Verify the proper functioning of the scavenger system.

Figure 6-2. Connecting the Open Reservoir Scavenger System



## Operating the Open Reservoir Scavenger System

Because the reservoir canister is open to the atmosphere, it does not require spring-loaded relief valves. If the waste gas flow rate from the patient breathing system exceeds the disposal system's suction flow rate, the canister initially accommodates excess waste gas. After excess waste gas fills the canister, waste gas then exits through the relief ports around the top of the canister. In this way, positive pressure does not build up within the patient breathing system.

**CAUTION:** Waste gas vented from the relief ports may contaminate the operating room. To prevent such contamination, be sure to adjust the needle valve properly.

If the disposal system's flow rate (suction) exceeds the waste gas flow rate from the patient breathing system, the disposal system draws room air through the relief ports. In this way, the disposal system does not apply a negative pressure to the patient breathing system.

## Adjusting the Needle Valve

Adjust the needle valve wing nut to regulate the waste gas exhaust flow and prevent waste gas contamination in the operating room.

To adjust the needle valve:

1. Attach all appropriate hoses and verify that the waste gas disposal system is active.
2. Turn the needle valve wing nut until the flowmeter indicates a flow halfway between the two white lines etched on the scavenger's flowmeter. This setting corresponds to a suction flow rate of about 25 l/min.

Depending on the fresh gas flow rate, the needle valve setting may need to be increased or decreased to settings either above or below the lines on the flowmeter. If the suction flow rate is set too low, waste gas will exit the canister through the relief ports around the top of the canister and contaminate the operating room. If the suction flow rate is too high, the waste gas disposal system's suction capacity will be needlessly depleted and the system will be noisy.

The needle valve setting may need readjusting during a case. For example, a shared suction disposal system may give a varying suction flow rate, depending on the number of users at any given time.

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# 7

## Scavenger Interface for Passive Systems Operation

*This section describes the scavenger interface for passive systems used in the Narkomed MRI-2 anesthesia machine.*

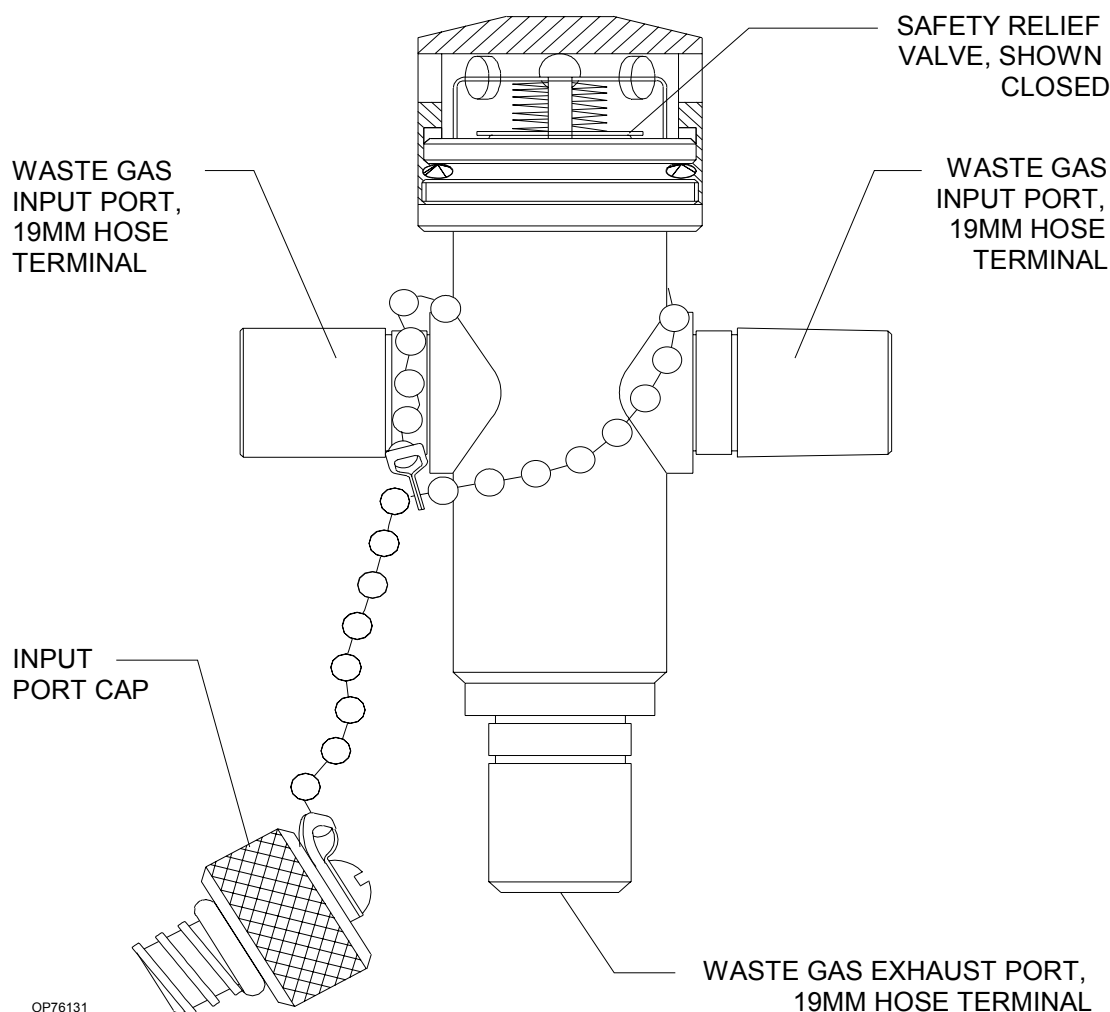
Overview .....	7-2
Operating the Scavenger Interface for Nonactive Systems .....	7-3

## Overview

The scavenger interface for passive systems is intended for use with nonrecirculating HVAC systems (also called exhaust systems). This scavenging approach relies on the waste gas pressure to transfer the gas from the scavenger to the disposal system. The scavenger interface is a “closed” system, which uses a spring-loaded valve for positive pressure relief.

**WARNING:** Do not use this device with a waste gas disposal system capable of applying a negative pressure to the scavenger interface (a suction or vacuum waste gas disposal system).

Figure 7-1. Scavenger Interface for Passive Systems

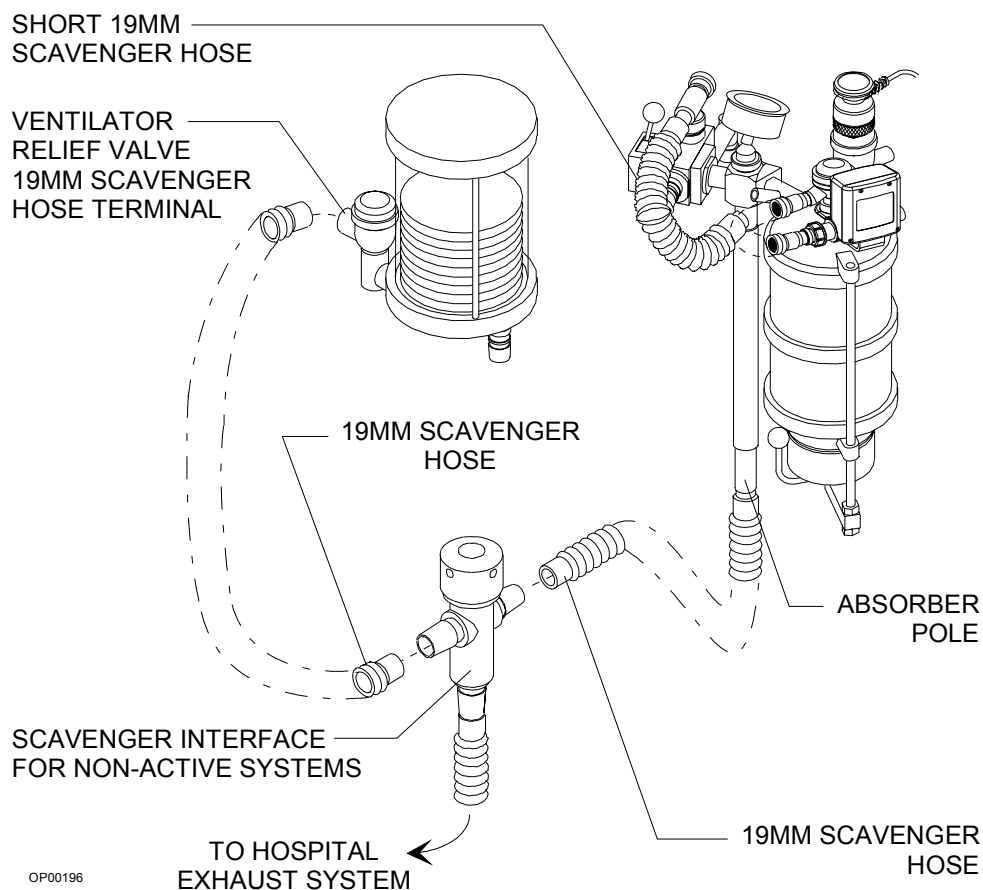


## Operating the Scavenger Interface for Nonactive Systems

In a typical anesthesia circle system, waste gas exits from the breathing system APL or ventilator relief valves and passes through the scavenger to the exhaust system. If the hospital exhaust system stopped functioning (or if the path between the scavenger and the exhaust system becomes blocked), positive pressure builds up within the scavenging and breathing systems. To prevent such a harmful pressure buildup, the scavenger's positive pressure relief valve is set to open at a pressure of 5 cm H<sub>2</sub>O. Waste gas then exits through the holes in the relief valve housing, so you do not need to adjust this scavenger. However, make sure that hoses are properly connected and that the positive pressure safety relief valve is functioning.

**WARNING:** The positive pressure relief valve must be inspected and cleaned (if necessary) at 6 month intervals.

Figure 7-2. Scavenger Interface Hose Connections



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# 8

## Main Switch Panel Operation

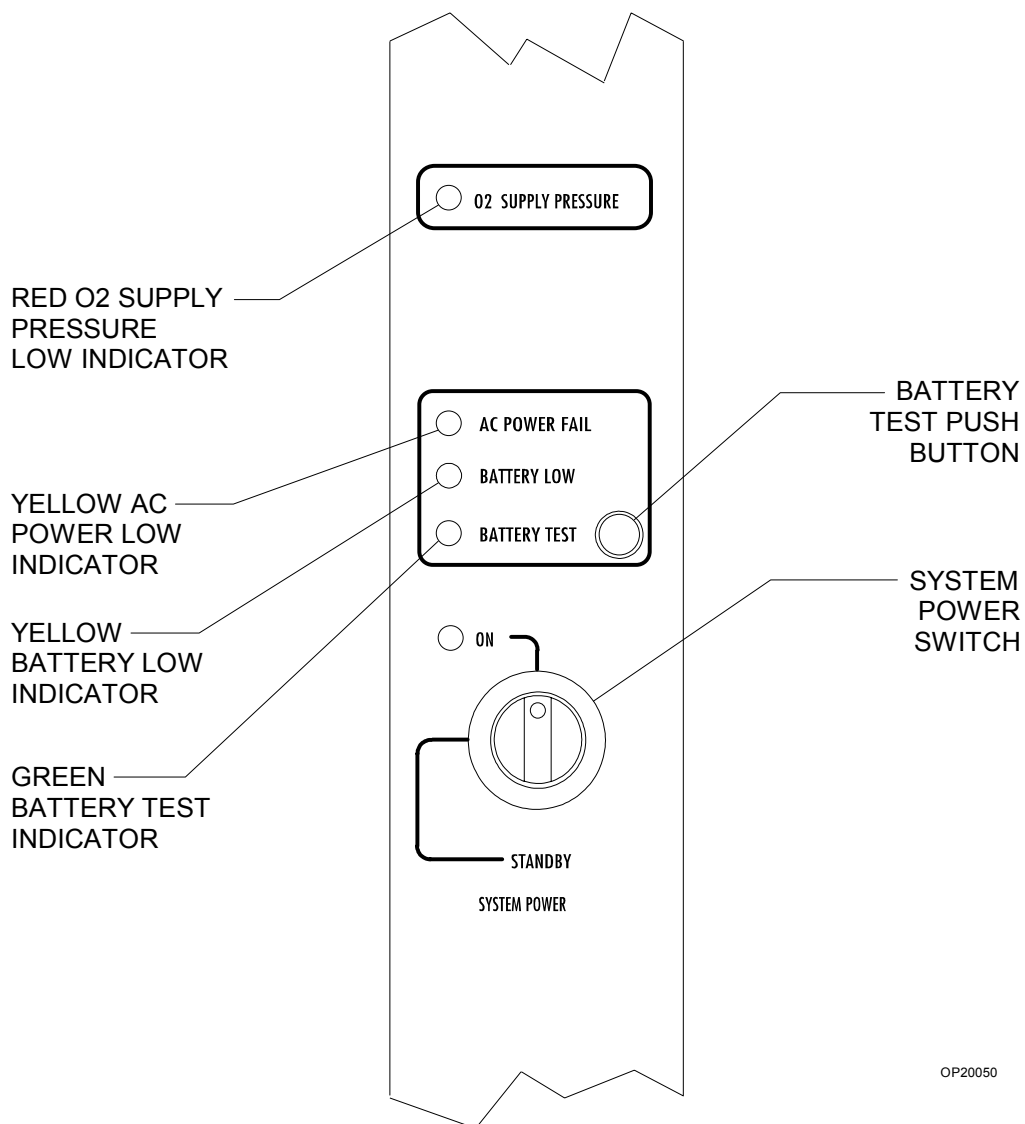
*This section describes the main switch panel in the Narkomed MRI-2 anesthesia machine.*

Overview .....	8-2
System Power Switch .....	8-3
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## Overview

The main switch panel, located between the ventilator bellows and flowmeter bank, incorporates the SYSTEM POWER switch and indicator lights for low O<sub>2</sub> supply pressure, AC power failure, and battery low alarms. A continuous alarm sounds when the O<sub>2</sub> supply pressure is low.

Figure 8-1. Main Switch Panel



## System Power Switch

The SYSTEM POWER switch has two positions\_ON and STANDBY. In the ON position, the gas (pneumatic) and electric power circuits for the ventilator and alarm system are turned on. The green indicator next to the switch lights. In the STANDBY position, the gas supplies and all electrical power to the ventilator, monitor, and alarm system are shut down. The battery charging circuit remains on.

**NOTE:** The battery charging circuit is active whenever the power cable is attached to an active wall receptacle, regardless of the switch setting.

## Testing the Battery

Test the battery system before each use. To test the battery:

1. Turn the SYSTEM POWER switch to ON.
2. Press and hold the BATTERY TEST button.
3. If the battery is sufficiently charged, only the green BATTERY TEST indicator lights.

A fully charged battery can power the electrical components of the anesthesia machine for up to three hours.

**NOTE:** The BATTERY LOW indicator lights when the battery reserve approaches depletion. **Do not** rely solely on this indicator for an assessment of battery capacity. Always perform the preuse battery test. If the battery becomes completely depleted and the machine does not have AC power, the BATTERY LOW indicator light has no source of power and does not function.

**WARNING:** **Do not** start an anesthetic procedure if the BATTERY LOW indicator light is illuminated.

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# 9

## AV2+ Ventilator Operation

*This section describes the AV2+ anesthesia ventilator in the Narkomed MRI-2 anesthesia machine.*

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Activating the Ventilator .....	9-3
Adjusting the Tidal Volume .....	9-4
Setting the Respiratory Frequency .....	9-4
Setting the Inspiratory/Expiratory (I:E) Phase Time Ratio .	9-5
Setting the Inspiratory Flow Rate .....	9-5
Setting the Inspiratory Pressure Limit .....	9-5
Problem Resolution .....	9-6

## Overview

The AV2+ anesthesia ventilator is a volume-preset, time-cycled, pressure-limited ventilator with electronic timing, pneumatic circuitry and independent controls for frequency, inspiratory-to-expiratory (I:E) ratio, inspiratory flow rate, tidal volume, and inspiratory pressure limit.

Pneumatic power (bellows drive gas) to the ventilator is supplied through the hospital oxygen pipeline supply or through the reserve cylinder on the anesthesia machine. The pressure of the supply gas must be between 40 and 60 psi. The ventilator will not function if this pressure drops below 32 psi. Electrical power is supplied by the AC power source or by the battery. A fully charged battery can power the ventilator for up to three hours.

The anesthesia ventilator is designed for use with a Draeger Medical absorber system, which incorporates a manual/automatic selector valve. This valve is for selecting either the breathing bag and adjustable pressure limiter (APL) valve for manual ventilation or the ventilator bellows for automatic ventilation.

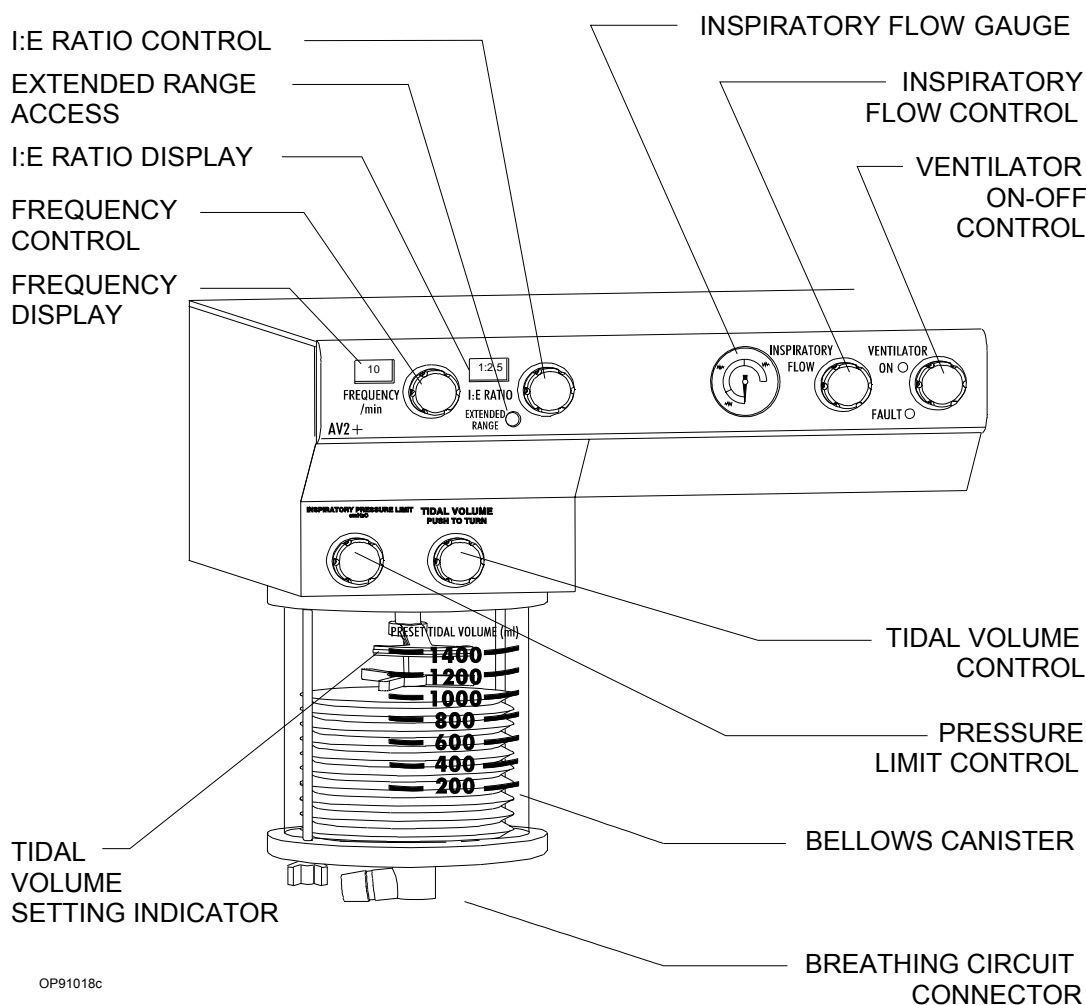
During automatic ventilation, the manual/automatic selector valve isolates the absorber's APL valve from the breathing system. To compensate for the continuous introduction of fresh gas into the breathing system, the ventilator incorporates a relief valve mounted behind the bellows chamber.

When the bellows is completely filled, any excess gas in the system is released to the scavenger system through the ventilator relief valve. As in any ascending bellows, the force needed to overcome gravity acting on the bellows causes a positive end-expiratory pressure (PEEP) within the breathing system. For the Narkomed MRI-2, the PEEP is about 2 cmH<sub>2</sub>O.

**WARNING:** Regardless of the indications of any alarm or monitoring device, patient chest movement must be the primary indication of a securely connected, properly ventilated patient.

A front view of the AV2+ anesthesia ventilator is shown in the following figure.

Figure 9-1. AV2+ Anesthesia Ventilator



OP91018c

## Activating the Ventilator

The ventilator is activated by using the ventilator ON/OFF control. The anesthesia machine's SYSTEM POWER switch must be set to ON for the ventilator to function.

When the ventilator is activated, the pneumatic and electric power to the ventilator are turned on and the alarm system is active. When the ventilator is turned off, the FREQUENCY and I:E RATIO displays remain lighted, but the ventilator does not function.

### Using the Ventilator ON/OFF Control

The ventilator ON/OFF control is a momentary switch that returns to its center position after being turned in either direction.

To activate the ventilator, turn the switch clockwise. The green ON indicator lights and the switch returns to its center position.

To shut down the ventilator, turn the switch counterclockwise. The green ON indicator is then turned off and the switch returns to its center position.

**NOTE:** The ventilator can not be turned on or off using the manual/automatic selector valve.

## Adjusting the Tidal Volume

The tidal volume is adjusted using a self-locking knob, located above the bellows assembly. The control knob positions a stop within the bellows canister that limits the upward travel of the bellows and sets the maximum tidal volume of gas delivered to the patient. To adjust the tidal volume, press the self-locking knob so it can turn, then set the preferred tidal volume by the setting indicator on the bellows chamber scale (marked 200–1400 ml). The tidal volume can be adjusted for volumes between 20 and 1500 ml.

Smaller tidal volumes can be adjusted by setting the pointer below the 200 ml marking on the bellows chamber. Larger tidal volumes can be selected by setting the pointer above the 1400 ml calibration.

As in any volume-preset anesthesia ventilator, the actual tidal volume delivered to the patient's lungs may differ from the preset volume at the bellows due to the compliance of the breathing system and fresh gas flow. To accurately set the tidal volume, refer to the tidal and minute volume measurements.

The position of the tidal volume indicator can be calibrated for a specific combination of fresh gas flow and equipment compliance by an authorized representative of DrägerService.

## Setting the Respiratory Frequency

Use the frequency control knob to set the respiratory frequency from 1 to 99 breaths per minute (BPM) in 1 BPM increments.

Rotating the control knob clockwise increases the frequency setting, while counterclockwise rotation decreases the frequency setting.

## Setting the Inspiratory/Expiratory (I:E) Phase Time Ratio

Use the I:E ratio control knob to set the inspiratory/expiratory (I:E) phase-time ratio. The standard range is from 1:1 through 1:4.5, adjustable in increments of 0.5.

An extended range of ratios is also possible for setting inverse I:E ratios. The specific extended range settings are: 4:1, 3:1, and 2:1. The extended ranges are set by pressing the EXTENDED RANGE switch while rotating the I:E ratio control knob.

Rotating the control knob clockwise increases the I:E ratio setting, while counterclockwise rotation decreases the I:E ratio setting.

**WARNING:** Inverse I:E ratios introduce auto-PEEP.

## Setting the Inspiratory Flow Rate

Use the inspiratory flow control knob to set the inspiratory flow in the 10 l/min to 100 l/min range. This setting controls the gas flow rate into the bellows canister and the gas flow rate delivered to the patient.

Because of patient circuit variables such as lung compliance, fresh gas flow, airway resistance and equipment compliance, the flow gauge is labeled with nominal zones. The scale on the label is only a reference.

Adjust the flow setting to a point where the ventilator bellows is fully compressed (but not deformed) at the end of the inspiratory phase of the breathing cycle.

Use the inspiratory flow control to create an inspiratory plateau at the end of the inspiratory cycle and to affect the potential peak inspiratory pressure within the patient breathing system. Always check the pressure indicated by the breathing system pressure gauge and waveform when adjusting the inspiratory flow control.

## Setting the Inspiratory Pressure Limit

The pressure limit control, located above the bellows canister, is used to adjust the pressure limit. This control determines the maximum pressure delivered by the ventilator during the inspiratory phase of the respiratory cycle. The scale is only a reference, because of patient circuit variables. Read the pressure from the breathing system pressure gauge or the monitor.

When the pressure limit control is turned fully counterclockwise, the peak inspiratory pressure will be less than or equal to 15 cmH<sub>2</sub>O. When the control is turned fully clockwise, the peak inspiratory pressure is less than or equal to 120 cmH<sub>2</sub>O.

## Problem Resolution

PROBLEM	POSSIBLE CAUSE	REMEDY
Excessive PEEP	Improperly adjusted ventilator relief valve	Contact an authorized representative of DrägerService
	Insufficient suction scavenger flow setting	Increase suction scavenger flow valve
	Inverse I:E ratios	Reset ratios
Excessive NEEP	Excessive suction scavenger flow	Reduce suction scavenger flow rate
Bellows won't reach tidal volume stop setting during expiration	Frequency too high for selected tidal volume	Decrease frequency
		Increase expiratory phase time
	Improperly adjusted ventilator relief valve	Contact an authorized representative of DrägerService
	Breathing system leak	Repair leak
Ventilator won't cycle	Low oxygen supply pressure	Provide sufficient oxygen supply pressure
Bellows won't compress during inspiration	Absorber manual/automatic selector valve in BAG position	Place selector valve in AUTO position
	Inspiratory flow control setting on ventilator too low	Increase inspiratory flow control setting
	Frequency too high	Decrease frequency
	Inspiratory pressure limit setting on ventilator too low	Increase inspiratory pressure limit setting.

# 10

## Monitoring System

*This section describes the monitoring system of the Narkomed MRI-2 anesthesia machine.*

Overview .....	10-2
Power-On Screen .....	10-2
Monitor Screen and Controls .....	10-3
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Setting Alarms to Standby .....	10-10
Silencing Alarms .....	10-10

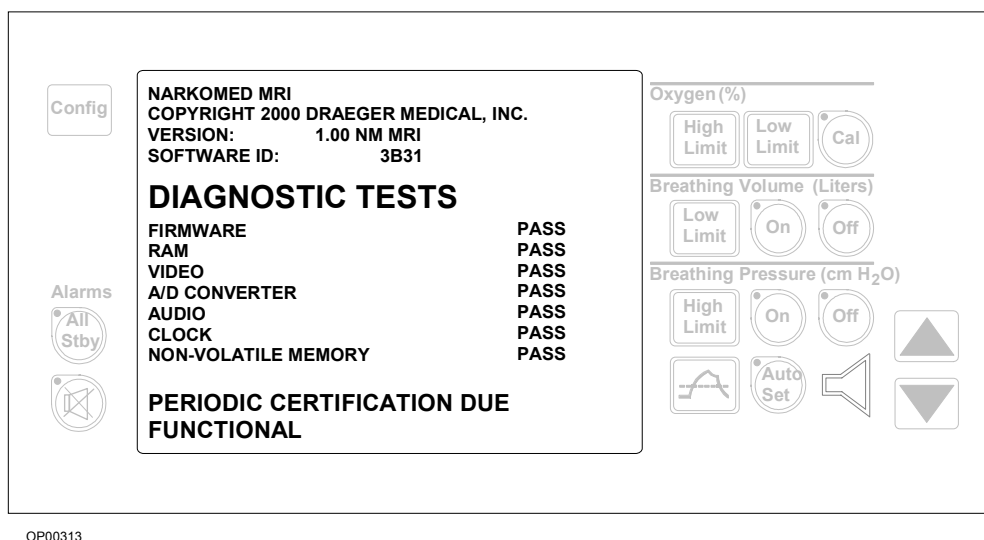
## Overview

In addition to monitoring clinical parameters, the Narkomed MRI-2 performs diagnostic self-tests every time the machine is turned on. After the initial power-on screen appears, the Monitor screen is displayed. This section of the manual describes these screens, and explains how to establish general monitoring settings.

## Power-On Screen

When you turn the SYSTEM POWER switch to the ON position, the Narkomed MRI-2 performs extensive self-tests on its internal hardware. As these diagnostics are performed, each test and its result appear on the screen. The result, PASS or FAIL, indicates the status of the tested component. See Figure 10-1.

Figure 10-1. Power-On Screen



At the end of the self-diagnostics, one of three possible conclusions to the self-tests is posted on the screen:

### FUNCTIONAL

Every component of the monitoring system is in satisfactory operational order. After a brief delay, the Monitor screen appears.

### CONDITIONALLY FUNCTIONAL

A noncritical fault was detected, such as a low inspiratory oxygen percentage. The Narkomed MRI-2 may be used, but an authorized representative of DrägerService should be notified to correct the problem.

When you are ready to resume operation, press any key on the keypad.

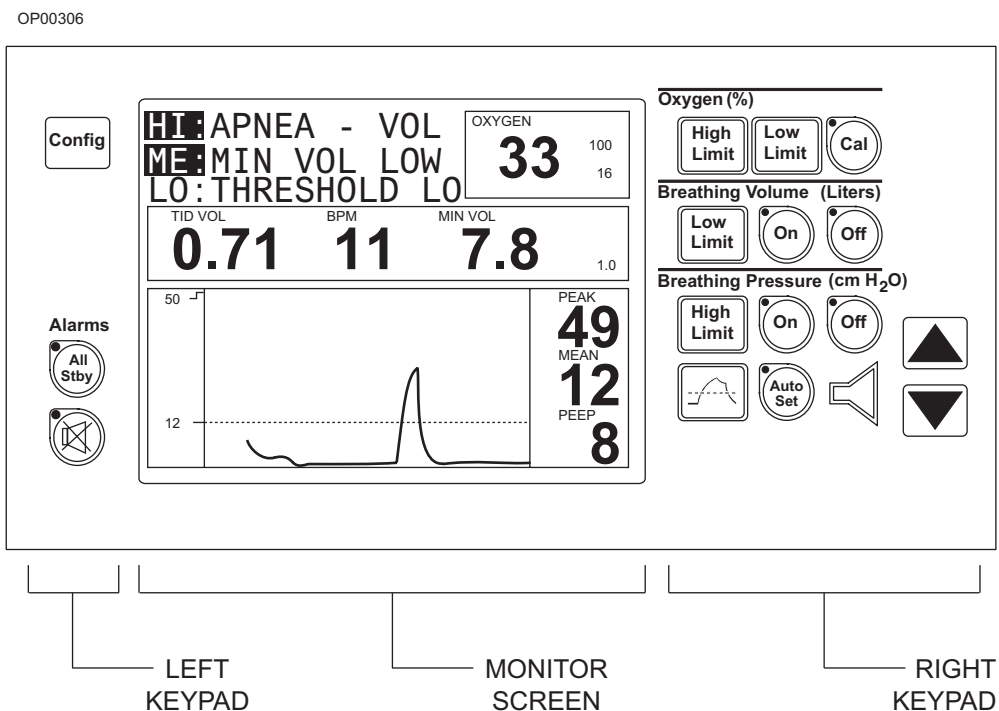
## NON-FUNCTIONAL

A serious fault was detected, such as an audio transducer failure, and operation of the monitor is inhibited. Do not use the machine. Immediately notify an authorized representative of DrägerService to correct the problem.

## Monitor Screen and Controls

Following a successful power-up, monitoring information is displayed on the Monitor screen. The control keys to the left and right of this screen allow you to establish monitoring settings. See Figure 10-2.

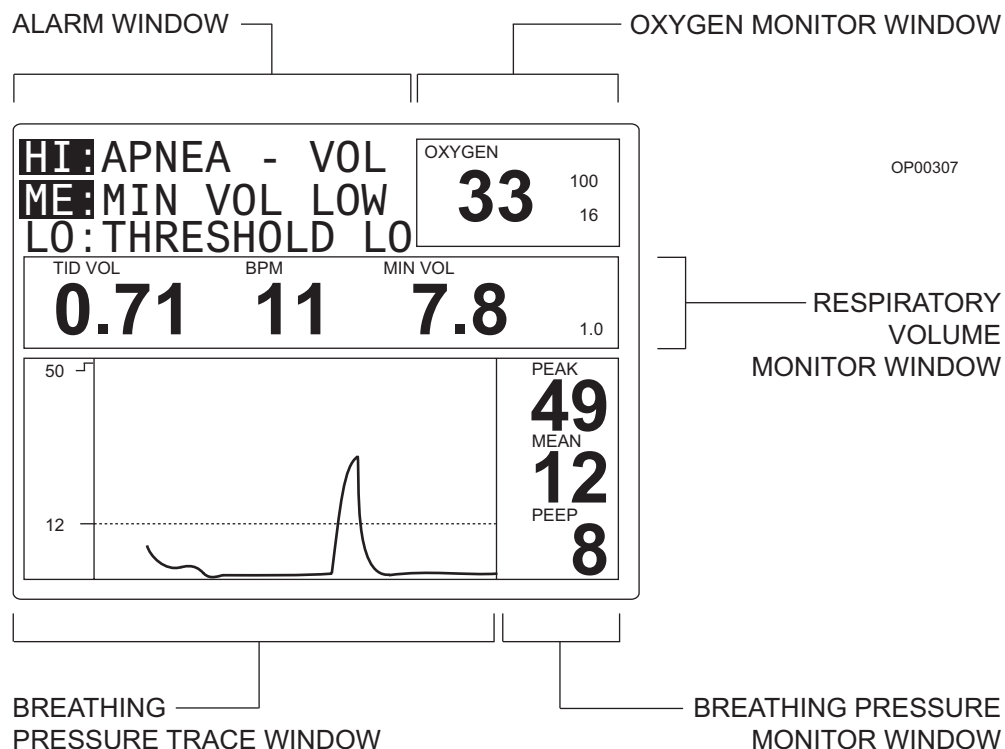
Figure 10-2. Monitor Screen and System Controls



## Monitor Screen

The Monitor screen displays information in five separate windows, as shown in Figure 10-3.

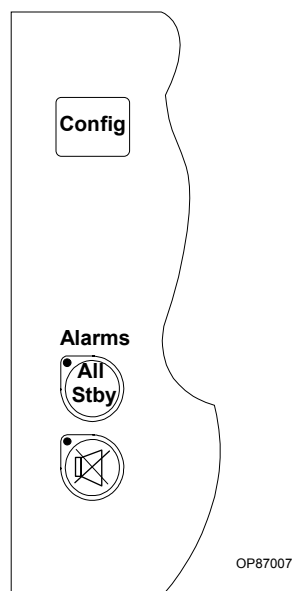
Figure 10-3. Monitor Screen



- **Alarm Window**—Displays up to three of the highest priority alarms.
- **Oxygen Monitor Window**—Displays the patient's oxygen concentration and the anesthesia machine's oxygen alarm limits.
- **Respiratory Volume Monitor Window**—Displays the patient's tidal volume, respiratory rate (breaths per minute), and minute volume, as well as the anesthesia machine's minute volume low alarm limit.
- **Breathing Pressure Monitor Window**—Displays the patient's peak airway pressure, mean airway pressure, and positive end expiratory pressure (PEEP).
- **Breathing Pressure Trace Window**—Displays a trace, or waveform, of the patient's breathing pressure, and the anesthesia machine's breathing pressure alarm limits (to the left of the waveform).

**Left Keypad** You use the left keypad to initiate system-wide monitoring functions.

**Figure 10-4. Left Keypad**



All Standby



When the ventilator is off, turns off audible tones and message displays associated with the breathing pressure alarm and respiratory volume alarms, until a valid breath is detected.

If the ventilator is on, only the respiratory volume alarms are affected.

Silence Alarms



Silences all audible alarm tones for 2 minutes.

Configure

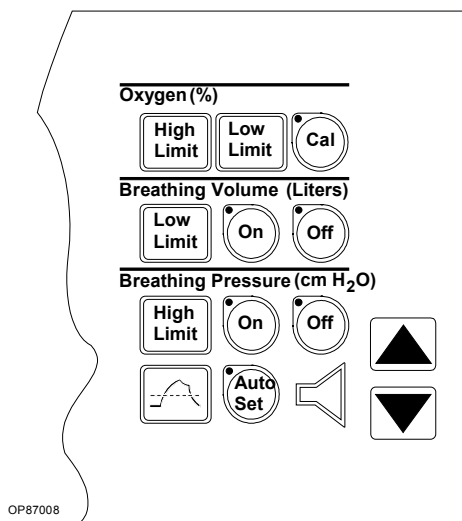


Displays the Configure screen, where you can set system parameters, such as the time, date, alarm volume, and contrast. You also enter the Alarm Log by way of the Configure screen.

These functions are described in detail later in this section.

**Right Keypad** You use the right keypad to perform functions associated with a specific monitor. These functions are described in the following sections: Section 11, "Oxygen Monitoring", Section 12, "Respiratory Volume Monitoring", and Section 13, "Breathing Pressure Monitoring".

**Figure 10-5. Right Keypad**



## Configuring the Anesthesia Machine

You can configure the following parameters on the Narkomed MRI-2:

- **Trace Speed**—Speed of the breathing pressure waveform trace: either FAST or SLOW
- **Current Time**—The current hour and minute in 24-hour format (*hour:minute*)
- **Current Date**—The current day, month, and year
- **LCD Contrast**—Adjusting the LCD contrast of the display

When you start the anesthesia machine, it uses the values that were established the last time the machine was configured. You can view or change these values on the Configure screen.

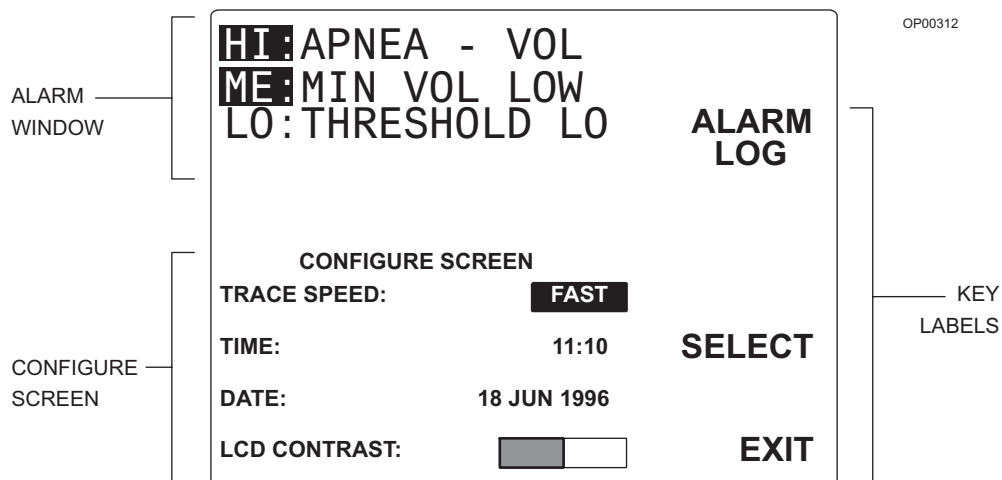
### Displaying the Configure Screen

Config

To display the Configure screen, press the Config key, which is located on the left keypad.

The Configure screen replaces the standard Monitor screen. You must begin configuration within 1 minute, or the Monitor screen will replace the Configure screen.




Figure 10-6. Configure Screen



## Understanding the Keys

When the Configure screen is displayed, the system control keys function according to the labels on the screen as explained in Table 10-1.

**Table 10-1. Control Key Functions in the Configure Screen**

Key	Label	Function
	ALARM LOG	Displays the Alarm Log, a separate screen that lists HI, ME, and LO messages that have occurred
	SELECT	Selects a parameter by highlighting it with a box
	EXIT	Exits the Configure screen and returns to the Monitor screen

## Changing Parameter Values



Follow this procedure for each parameter you want to change.

1. Press the SELECT key until the variable you want to change is highlighted with a box.
2. Press the up or down arrow key to increase or decrease the value of the highlighted variable.

## Exiting the Configure Screen



To exit the Configure screen immediately, press the EXIT key.

**NOTE:** The monitoring system automatically exits the Configure screen if a minute passes and no keys are pressed.

When you exit the Configure screen, the values displayed on the screen are saved. The monitoring system uses these values until they are changed.

## Using the Alarm Log

If you miss a HI or ME message in the Alarm window, you can look for it in the Alarm Log. It contains up to 100 of the most recent HI and ME messages. When there are more than 100 HI and ME messages, the oldest message is deleted to make room for the newest.

## Displaying the Alarm Log



Follow this procedure to display the Alarm Log.

1. From the Monitor screen, press the Config key.

The Configure screen is displayed.

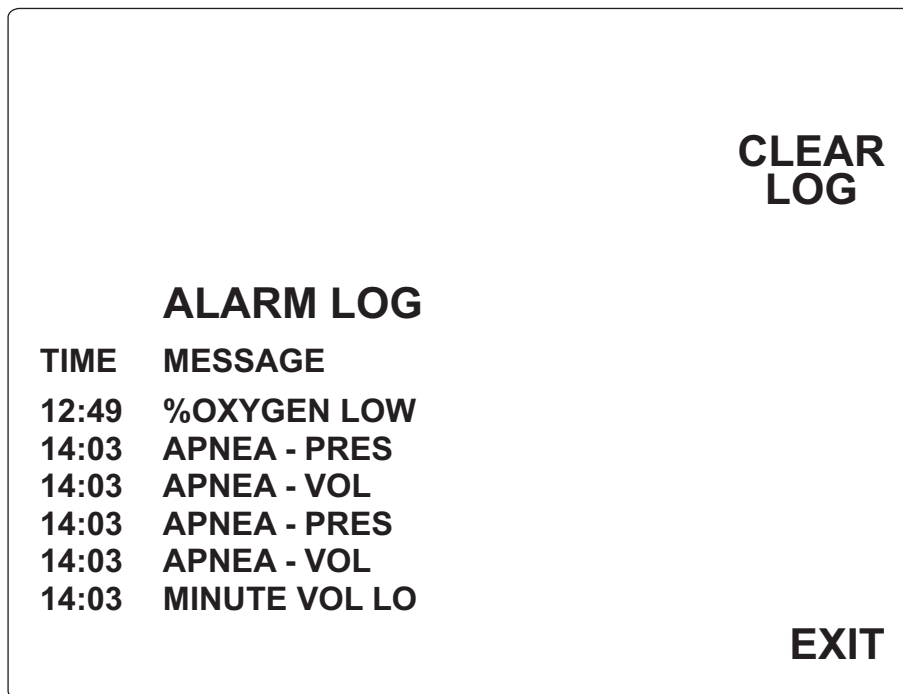
Low  
Limit

2. From the Configure screen, press the ALARM LOG key.

The Alarm Log appears, with the first HI or ME message that occurred at the top of the list.

3. If the list extends beyond the page, scroll forward by pressing the down arrow key, and scroll backward by pressing the up arrow key.

Figure 10-7. Alarm Log



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Clearing the  
Alarm Log

High  
Limit

To delete all of the messages from the Alarm Log, press the CLEAR LOG key.

The messages are permanently deleted from the Log.

Exiting the  
Alarm Log



To exit the Alarm Log immediately, press the EXIT key.

**NOTE:** The monitoring system automatically exits the Alarm Log if a minute passes and no keys are pressed.

When you exit the Alarm Log, you are returned to the Monitor screen.

## Setting Alarms to Standby



When the ventilator is off, you can use the All Stby key to turn off audible tones and message displays associated with the breathing pressure alarm and respiratory volume alarms. The alarms remain in this standby condition until the monitor detects a valid breath.

**NOTE:** When the ventilator is on, pressing the All Stby key places the volume alarm in Standby until the next breath is detected. It has no effect on the pressure alarm. The pressure alarm cannot be turned off when the ventilator is on.

To set alarms to standby, press the All Stby key.

The LED next to the All Stby key lights to indicate the standby condition.

## Silencing Alarms



You can silence all audible alarm tones for 2 minutes while retaining the alarm message display on the monitor.

To silence alarm tones for 2 minutes, press the Silence Alarms key.

The LED next to the Silence Alarms key lights and remains lit for the duration of the silence period. Pressing the Silence Alarms key while the LED is lit restarts the 2-minute silence period.

If a new alarm condition occurs during the silence period, a single tone pattern sounds corresponding to the priority of the alarm.

After the silence period, one of the following occurs:

- If no alarm conditions are active, audio annunciation reverts to normal.
- If any HI or ME conditions are active, the tone associated with the highest existing alarm condition sounds. The alarm continues to sound once every minute, for up to 3 minutes, or until alarm conditions have been cleared for 10 seconds.

**NOTE:** All continuous audible alarms are automatically silenced for 2 minutes following power-up. During this period, the occurrence of a new alarm produces a non-repeating tone pattern appropriate for that alarm's level of urgency.

# 11

## Oxygen Monitoring

*This section describes the oxygen monitoring of the Narkomed MRI-2 anesthesia machine.*

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## Overview

Inspiratory oxygen concentration is measured with a dual galvanic cell sensor, which is attached to the inspiratory valve dome. The sensor contains two independent electrochemical cells, or sensor halves. When the sensor takes in oxygen, an electrochemical reaction occurs within each cell. The oxygen monitor reads the voltage produced in each cell, computes an average for the two cells, and translates the average into an oxygen concentration measurement.

**CAUTION:** Never remove an oxygen sensor from its housing, except to replace it. If a sensor is removed from its housing, you must do the following before continuing normal operations:

- Reinstall the sensor in the housing.
- Wait for a period equal to the time that the sensor spent outside the housing.
- Calibrate the sensor.

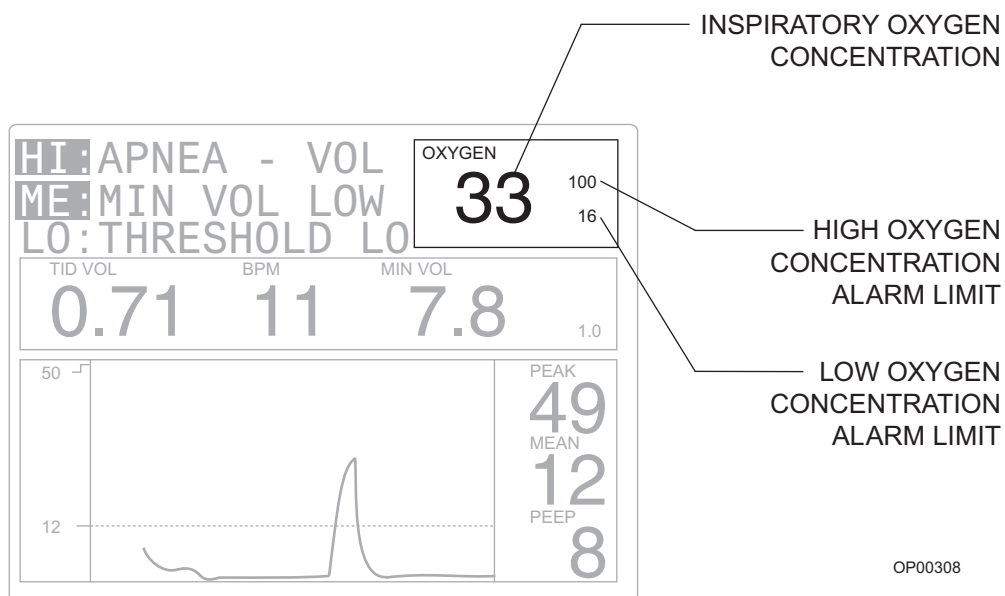
**CAUTION:** Only the oxygen sensor assembly supplied with a Narkomed MRI-2 should be used. Use of any other oxygen sensor assembly may result in the corruption of the MRI image.

**NOTE:** When the machine is not in use, remove the oxygen sensor assembly from the inspiratory valve dome, and insert the inspiratory valve dome plug into the inspiratory valve dome.

## Monitor Display

Information about the oxygen analysis is presented in the Oxygen Monitor window at the top right of the monitor display as shown in Figure 11-1. The numerical value for inspiratory oxygen concentration is shown in large type. To the right of this figure, in small type, are the high and low oxygen concentration alarm limits.

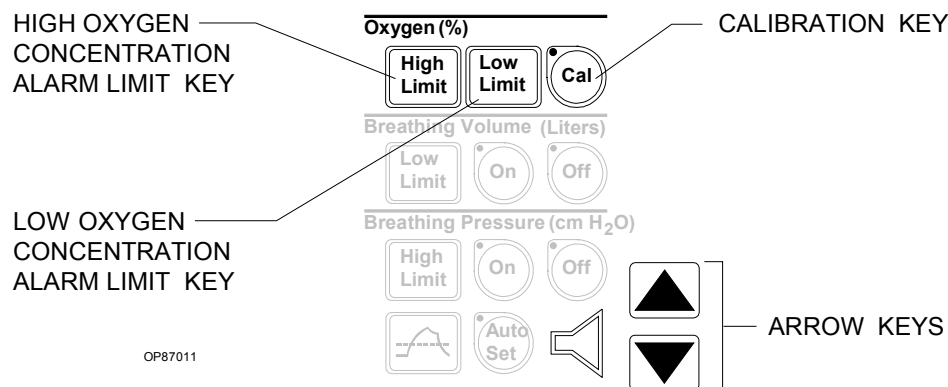
Figure 11-1. Monitor Display



## Monitor Controls

You use the oxygen monitor control keys and the arrow keys on the right keypad to set oxygen concentration alarm limits and calibrate the oxygen sensor. The oxygen monitor control keys are located next to the Oxygen Monitor window. See Figure 11-2.

Figure 11-2. Monitor Controls



## Setting Alarm Limits



At power-up, the oxygen high and low alarm limits are automatically set to their system defaults. You can adjust these limits within specified ranges. Valid settings for the alarm limits, and their system defaults, are shown in Table 11-1.

Table 11-1. Alarm Limits

Alarm Limit	Default	Valid Settings
High	100%	19%–100%; must be greater than low alarm limit
Low	30%	18%–99%; must be less than high alarm limit

Follow these steps to change the high or low alarm limit:

1. Press the oxygen High Limit or Low Limit key, depending on which alarm limit you want to change.

A box is drawn around the selected alarm limit.

2. Press the up arrow or down arrow key to increase or decrease the highlighted alarm limit.
3. To save the new value, stop pressing arrow keys until the highlighting box disappears (5 seconds), or press a different alarm limit key.

The new value is saved as the alarm limit.

## Calibrating the Oxygen Sensor



To calibrate the oxygen sensor correctly, make sure it is exposed only to room air during the entire calibration period. You should calibrate the oxygen sensor as part of the daily preoperative setup of the anesthesia equipment. Refer to Figure 11-3.

1. Remove the sensor assembly from the inspiratory valve dome and close off the dome with the inspiratory valve dome plug. (Do not disassemble the sensor assembly further.)
2. Expose the sensor to ambient air only (21% oxygen concentration) and allow it to stabilize for several minutes. To ensure an ambient air

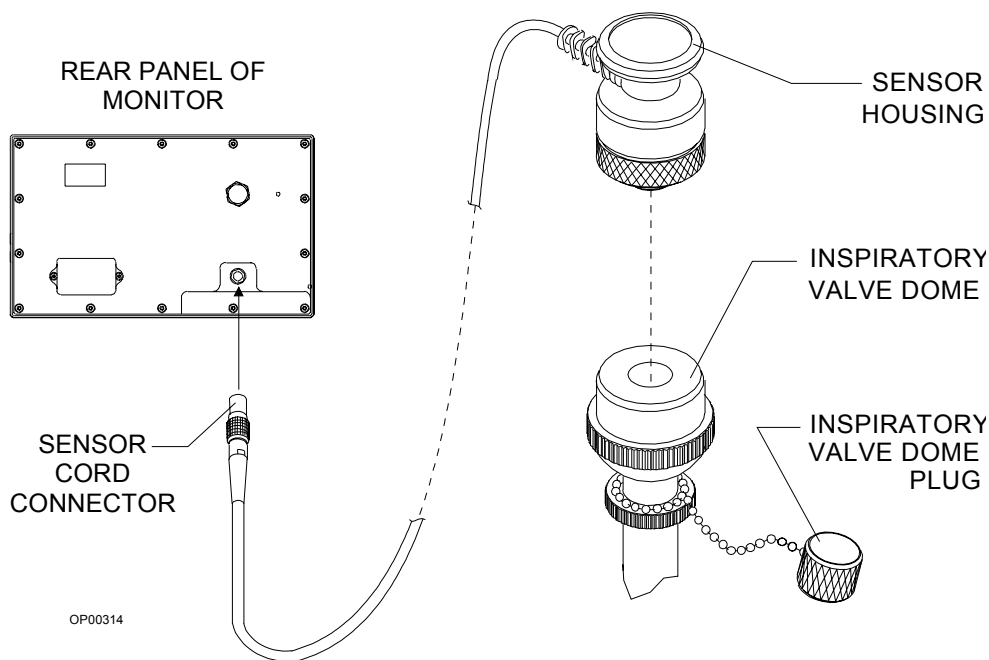
exposure, hold the sensor away from any open part of the breathing system.

3. With the sensor exposed only to room air, press the Cal key.  
Calibration begins.
4. View the monitor screens to track progress of the calibration.
  - During calibration, the LED next to the Cal key lights, and the label CAL appears in the Oxygen Monitor window.
  - Following successful calibration, the currently sensed oxygen concentration appears in the Oxygen Monitor window. (If the calibration was not successful, the Oxygen Monitor window is blank. See “Unsuccessful Calibration” on page 11-7 for further information.)

Typically, calibration lasts less than 30 seconds. However, the time may vary depending on the amount of oxygen the sensor was exposed to before calibration.

<u>Oxygen Exposure</u>	<u>Typical Calibration Time</u>
21%	10 seconds
> 21%	up to 50 seconds

**Figure 11-3. Calibrating the Oxygen Sensor**



5. When the Narkomed MRI-2 successfully completes the calibration, pull the inspiratory valve dome plug and reinsert the sensor assembly.

## Unsuccessful Calibration

If, at the end of the calibration period, the Oxygen Monitor window is blank, the calibration was not successful. This condition is also indicated by the O2 CAL DUE (oxygen sensor should be calibrated; more than 18 hours have passed since calibration), O2 CAL ERR (oxygen percentage greater than 103%), or O2 NOT CAL (unit did not calibrate properly due to sensor error condition during calibration) LO messages in the Alarm window.

An unsuccessful calibration can also be caused by several other conditions as described in Table 11-2.

**Table 11-2. Unsuccessful Calibration - Causes and Solutions**

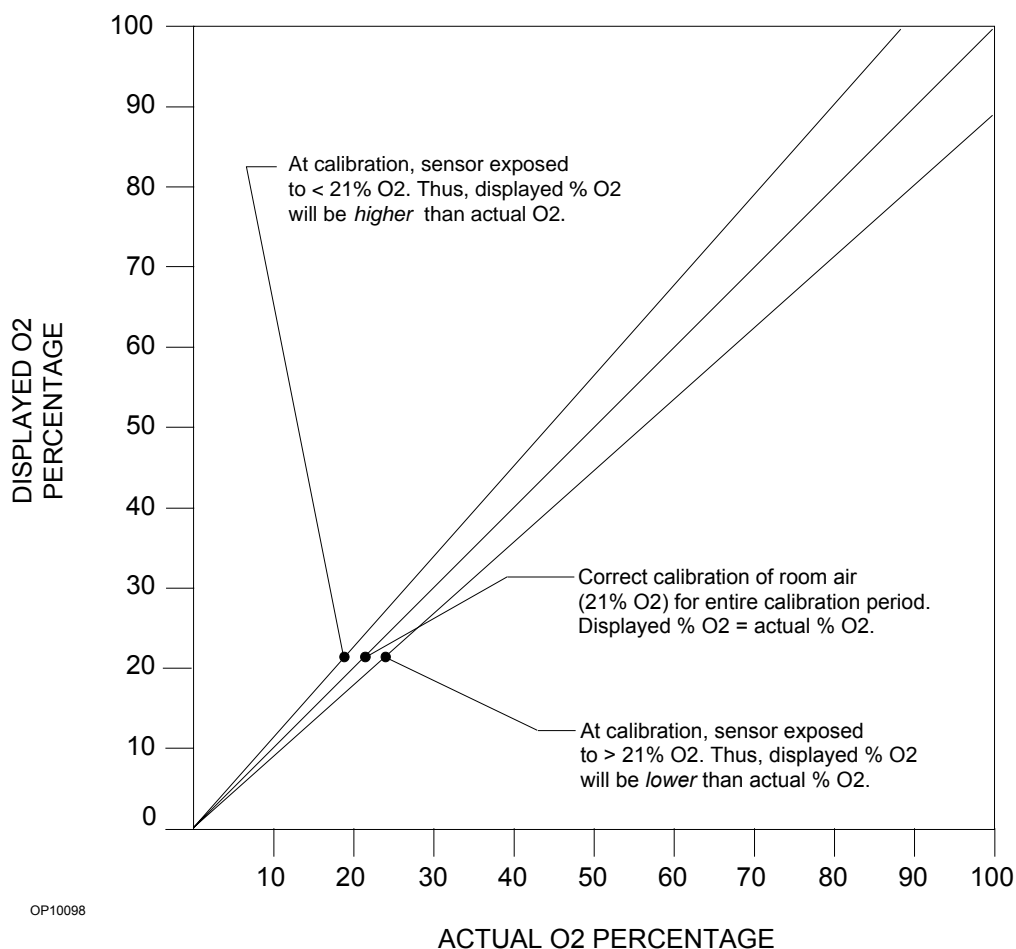
Cause	Solution
Sensor was exposed to an excessively lean or excessively rich oxygen calibration mixture.	Make sure that the sensor is exposed to room air only for the entire calibration period.
Sensor was exposed to a constantly changing calibration mixture.	Make sure that the sensor is exposed to room air only for the entire calibration period.
Sensor did not receive the proper waiting period.	If the sensor capsule was removed from the sensor assembly, a waiting period equal to the time that the capsule spent outside the sensor assembly (up to one week) is necessary prior to calibration. New sensors require a 15-minute waiting period.
Sensor is exhausted.	If the oxygen sensor has decayed beyond its useful service life (see the "Specifications" section of the manual), replace the decayed sensor with a new sensor and allow the proper waiting period.
Sensor is defective.	If there is too great a difference between the outputs of the two sensor halves, replace the defective sensor with a new sensor, and allow the proper waiting period prior to calibration.
Sensor is disconnected.	When the sensor is disconnected, the display area is blank, and the message O2 SENS DISC appears in the Alarm window. If this happens, reconnect the sensor cord to the OXYGEN SENSOR interface beneath the rear panel of the ventilator box and try to calibrate the oxygen sensor again.

## Consequences

If the oxygen sensor is improperly calibrated, it can cause inaccurate measurements. When a calibration gas mixture is excessively rich or lean in oxygen, the Narkomed MRI-2 will not complete an attempted calibration; however, if the calibration gas is rich or lean but is within certain limits, the Narkomed MRI-2 will complete the calibration. As a result, when displaying sensor measurements, the Narkomed MRI-2 displays an oxygen percentage either greater or less than the actual oxygen percentage. Therefore, make sure that the sensor is exposed only to room air during the entire calibration period.

Figure 11-4 illustrates the relationship between the calibration mixture and the accuracy of oxygen measurement.

Figure 11-4. Measurement Error Due to Incorrect Calibration



## Oxygen Alarm Messages

The following list contains all HI, ME, and LO alarms associated with oxygen monitoring.

### **%OXYGEN LOW (HI)**

The Narkomed MRI-2 continuously compares the current inspiratory oxygen percentage with the preset low oxygen alarm limit. If the measured oxygen concentration falls below the low alarm limit, the HI message %OXYGEN LOW appears in the Alarm window, and a continuous audible alarm sounds.

### **%OXYGEN HIGH (LO)**

If the measured inspiratory oxygen concentration exceeds the preset high alarm limit, the LO message %OXYGEN HIGH appears in the Alarm window, and a single-tone audible alarm sounds.

### **O2 SENS DISC (LO)**

If the oxygen sensor cord becomes disconnected (or is damaged enough to cause an open circuit), the LO message O2 SENS DISC appears in the Alarm window, and a single-tone audible alarm sounds.

### **O2 CAL DUE (LO)**

The LO message O2 CAL DUE appears in the Alarm window when the oxygen sensor needs to be calibrated (more than 18 hours have elapsed since the last calibration).

During oxygen sensor calibration, the Narkomed MRI-2 checks the sensor's output against a range of acceptable output voltages. There are three possible causes for deviation from within this range.

- *Exhausted sensor.* If the sensor's capacity is exhausted, its output voltage will not meet the required minimum.
- *Incorrect calibration environment.* If the sensor is exposed to an excessive oxygen during calibration, the sensor's output will be above or below the acceptable output range.
- *Improper waiting.* If the proper waiting period is not allowed for a new sensor or for a sensor removed from the sensor housing, the sensor's output may be above or below the acceptable output range.

If a sensor error condition is detected during monitoring, the LO message O2 CAL DUE, O2 CAL ERR, or O2 NOT CAL appears in the Alarm window and operation continues. Try to recalibrate the sensor; if the message remains, replace the sensor cell.

### **O2 CAL ERR**

The LO message O2 CAL ERR appears in the Alarm window when the oxygen percentage is greater than 103%.

If a sensor error condition is detected during monitoring, the LO message O2 CAL DUE, O2 CAL ERR, or O2 NOT CAL appears in the Alarm window and operation continues. Try to recalibrate the sensor; if the message remains, replace the sensor cell.

**O2 NOT CAL** The LO message O2 NOT CAL appears in the Alarm window when the unit did not calibrate properly due to sensor error condition during calibration.

If a sensor error condition is detected during monitoring, the LO message O2 CAL DUE, O2 CAL ERR, or O2 NOT CAL appears in the Alarm window and operation continues. Try to recalibrate the sensor; if the message remains, replace the sensor cell.

**SERVICE VENT MON (LO)** If the Narkomed MRI-2 detects an internal electronic failure that would prevent proper operation, the LO message SERVICE VENT MON appears in the Alarm window. If this happens, contact an authorized representative of DrägerService.

## Low Oxygen Supply Whistle

If the Narkomed MRI-2 is configured to do so, it sounds a 10-second whistle when the oxygen supply drops too low to properly pressurize the fresh gas circuit (below about 37 psi). If this alarm sounds, it cannot be silenced.

## Problem Resolution

Table 11-3. Oxygen Monitoring Problem Resolution

PROBLEM	POSSIBLE CAUSE	REMEDY
Display area remains blank when a reading is expected. O2 NOT CAL message appears in Alarm window.	Needs calibration	Perform proper calibration. Remove sensor assembly from breathing circuit. Make sure sensor is exposed to room air only. Then press the Cal key.
O <sub>2</sub> analyzer fails to retain calibration. O2 NOT CAL message appears in Alarm window.	Backup memory power not available	Check battery circuit breaker.  Allow backup battery to recharge, and recalibrate the analyzer.
	Hardware malfunction	Contact an authorized representative of DrägerService.

PROBLEM	POSSIBLE CAUSE	REMEDY
Pressing Cal does not initiate calibration. O2 SENS DISC message appears in Alarm window.	Sensor is disconnected	Insert sensor cord connector into OXYGEN SENSOR interface underneath rear panel of ventilator box.
	Sensor cord is damaged	Replace housing/cord assembly.
Pressing Cal initiates calibration, but Oxygen Monitor window is blank at end of calibration period. O2 NOT CAL message appears in Alarm window.	Sensor is exposed to incorrect oxygen concentration.	Expose sensor to room air for 21% calibration.
	Sensor exposed to constantly changing calibration mixture.	
	Sensor capsule was removed from housing for a prolonged period.	Allow a waiting period equal to duration of capsule removal.
	New capsule not given proper waiting period.	Allow 15 minute waiting period.
	Exhausted or defective sensor capsule.	Replace housing/cable assembly.
O2 SENS DISC message appears in alarm window during monitoring.	Defective sensor housing and cable.	Replace housing/cable assembly.
	Sensor cord is disconnected.	Insert sensor cord connector into OXYGEN SENSOR interface underneath rear panel of ventilator box.

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# 12

## Respiratory Volume Monitoring

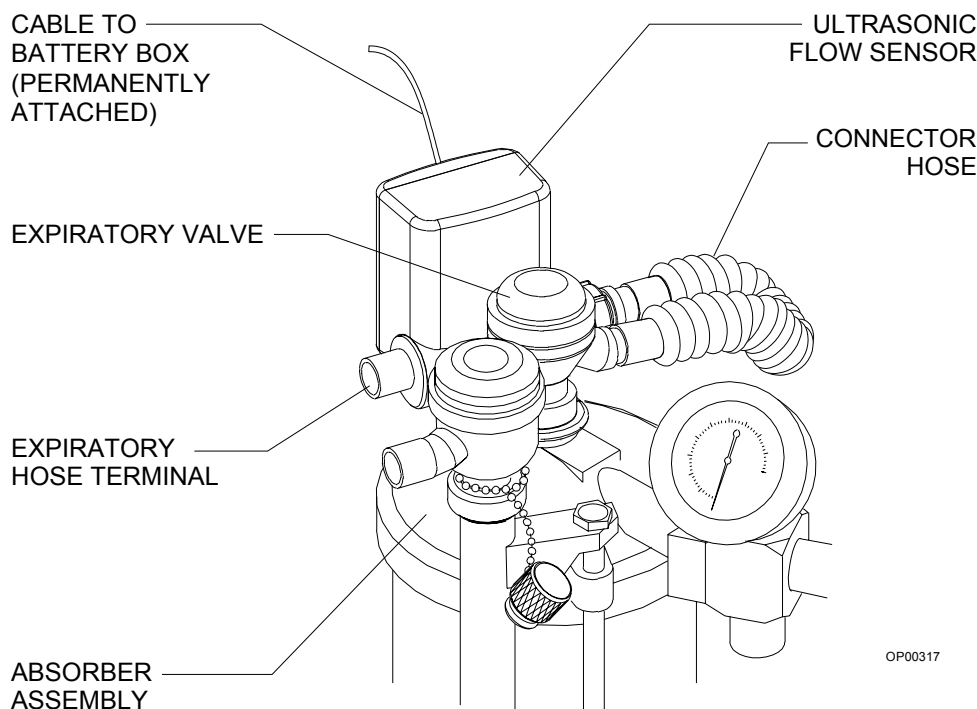
*This section describes the respiratory volume monitoring of the Narkomed MRI-2 anesthesia machine.*

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## Overview

Respiratory volume is measured using an ultrasonic flow sensor which is attached to the expiratory valve and mounted to the top of the absorber assembly as shown in Figure 12-1. The ultrasonic flow sensor has two transducers that measure the time of flight of ultrasonic pulses transmitted upstream and downstream in the respiratory flow path. The difference in time of flight is used to determine the velocity and the flow rate of gas through the patient circuit. The flow sensor output is converted into meaningful readings for minute volume, tidal volume, and respiratory rate displays.

**Figure 12-1. Respiratory Volume System**



**WARNING:** The ultrasonic flow sensor can be used with all normal anesthetic gases except oxygen-helium (heliox). Incorrect flow measurements will result if heliox is used.

**CAUTION:** Although the Narkomed MRI-2 is designed to minimize the effects of ambient radio-frequency interference, the functioning of the respiratory volume monitor may be adversely affected by the operation of electrosurgical equipment or short wave or microwave diathermy equipment in the vicinity.

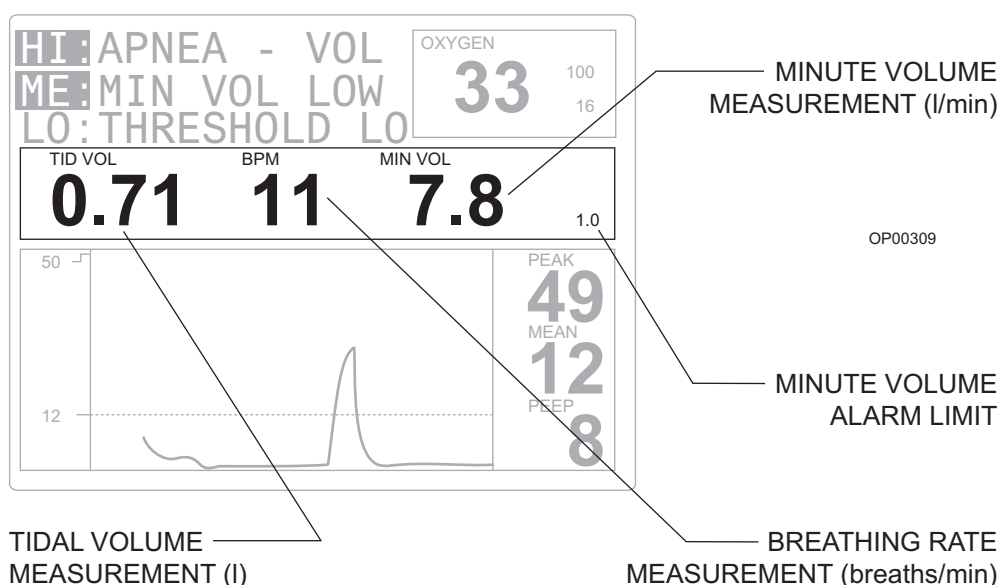
**NOTE:** Sudden, irregular expiratory flow may cause erratic tidal volume and respiratory rate displays. To avoid such

erroneous measurements, defer reading the display until a full minute has elapsed after the irregular flow has stopped.

## Monitor Display

Information about the patient's respiratory volume is presented in the Respiratory Volume Monitor window in the middle of the monitor display as shown in Figure 12-2. From left to right, numerical values are shown in large type for tidal volume, respiratory rate, and minute volume. At the extreme right, in small type, is the minute volume low alarm limit.

Figure 12-2. Monitor Display

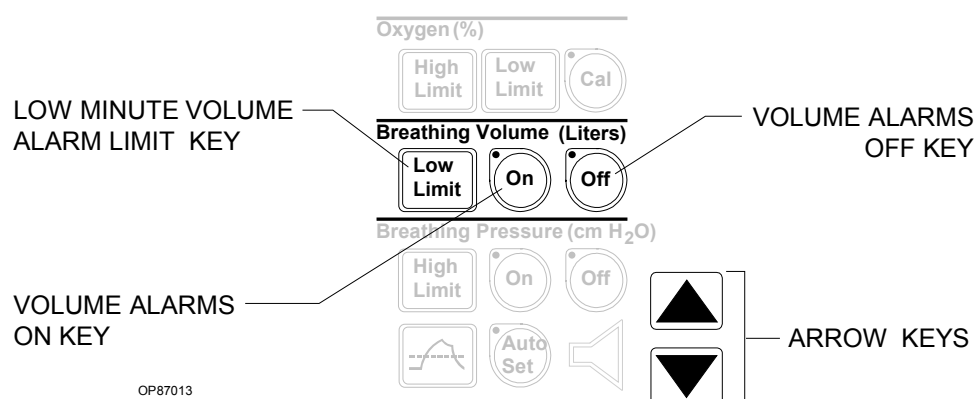


- **Tidal Volume Measurement (TID VOL)**—Displays the volume for each breath. If the monitor does not detect a valid breath within 30 seconds, the display area goes blank.
- **Breathing Rate Measurement (BPM)**—Shows the number of breaths during the previous minute of respiration. If the BPM display is blank, a full minute of respiration has not occurred.
- **Minute Volume Measurement (MIN VOL)**—Continuously displays the volume of exhaled gas accumulated during the previous minute of respiration. A blank MIN VOL display area indicates that a full one-minute history of exhaled volume is not available.
- **Minute Volume Alarm Limit**—Indicates the volume below which an alarm condition occurs.

## Monitor Controls

You use the respiratory volume monitor control keys and the arrow keys on the right keypad to set the minute volume low alarm limit and to turn the volume alarms on and off. The respiratory volume monitor control keys are located next to the Respiratory Volume Monitor window. See Figure 12-3.

Figure 12-3. Monitor Controls



Fixed alarms are provided for low tidal volume (apnea-volume), low minute volume, and reverse flow through the sensor. While the ventilator is on, apnea volume alarms are generated at 15 seconds (ME) and 30 seconds (HI) if the respiratory volume monitor does not sense a valid breath. While the ventilator is off, these alarms are generated at 30 seconds (ME) and 60 seconds (HI).

The Narkomed MRI-2's volume alarms are automatically enabled when the ventilator power switch is turned to the ON position. A disconnected or damaged sensor causes a sensor failure alarm.

## Setting the Minute Volume Low Alarm Limit

If the low minute volume falls below the minute volume low alarm limit, an alarm condition occurs. The alarm limit is automatically set to a default of 1.0 liter/min. at power-up. You can change the default to a value within the range of 0.2 liters/min. to 10.0 liters/min.

Follow these steps to adjust the minute volume low alarm limit:

1. Press the Breathing Volume Low Limit key.  
A box is drawn around the minute volume low alarm limit.
2. Press the up arrow or down arrow key to increase or decrease the highlighted alarm limit.
3. To save the new value, stop pressing arrow keys until the highlighting box disappears (5 seconds), or press a different alarm Limit key.  
The new value is saved as the alarm limit.

## Turning Respiratory Volume Alarms Off

To turn off the respiratory volume alarms, press the Breathing Volume Off key.

The alarms stop sounding and their messages are erased from the display. In addition, the LED next to the Breathing Volume Off key lights to indicate the Off condition.

## Turning Respiratory Volume Alarms On

To turn on the respiratory volume alarms, press the Breathing Volume On key.

The LED next to the Breathing Volume On key lights to indicate that the volume alarms are enabled.

**NOTE:** After power-up, the volume alarms are in standby.

## Respiratory Volume Alarm Messages

The following list contains all HI, ME, and LO alarms associated with respiratory volume monitoring.

### APNEA-VOL (HI/ME)

The Narkomed MRI-2 continuously monitors the expiratory flow in the patient breathing system. By processing the expiratory flow pattern, the monitor can determine whether a “valid” breath has occurred. A “valid” breath has a tidal volume of 20 ml or greater.

#### When the ventilator is on:

- If 15 seconds pass and a valid breath is not detected, the ME message APNEA-VOL appears in the Alarm window, and an intermittent audible alarm sounds.
- If an additional 15 seconds pass (30 seconds total) and a valid breath is not detected, the ME message APNEA-VOL is upgraded to HI in the Alarm window, and a continuously repeating audible alarm sounds.

#### When the ventilator is off:

- The ME condition does not occur until 30 seconds have elapsed.
- The HI condition does not occur until 60 seconds have elapsed.

During apneic conditions, the respiratory volume measurements disappear after 30 seconds. When a valid breath is detected, alarm annunciation ceases and a tidal volume measurement appears in the display window. However, a full minute of respiratory activity must be registered before the minute volume and respiratory rate appear.

**NOTE:** You can disable volume-related alarms by pressing the Breathing Volume Off key.

**NOTE:** During some breathing system disconnects when the ventilator is in use, the ventilator's dynamics may cause a small volume of gas to be drawn through the expiratory valve and the ultrasonic flow sensor. Because of the enhanced sensitivity of the flow sensor, this volume may be detected as a valid breath. However, the disconnect will still be detected by the airway pressure monitor which is always on and can not be turned off when the ventilator is in use.

### MIN VOL LOW (ME)

Whenever the Narkomed MRI-2 measures a minute volume less than the low minute volume alarm limit, the ME message MIN VOL LOW appears in the Alarm window, and an intermittent audible alarm sounds.

### REVERSE FLOW (LO)

If a reverse flow in excess of 20 ml is detected, the LO message REVERSE FLOW appears in the Alarm window, and a single-tone audible alarm sounds.

A forward flow greater than 20 ml clears the alarm condition. The REVERSE FLOW alarm message remains on the screen for 5 seconds after the resumption of forward flow to allow for recognition of an intermittent reverse flow condition.

**VOL SEN  
DISC (LO)**

The VOL SEN DISC (LO) message appears in the Alarm window if there is an internal sensor fault, or if the electronics housing is not properly seated on the flow housing/transducer assembly.

**VOL ALM  
STBY (LO)**

When the volume alarms have been set to Standby, the LO message VOL ALM STBY appears in the Alarm window.

**SERVICE  
VENT MON  
(LO)**

If the Narkomed MRI-2 detects an internal electronic failure that would prevent proper operation, the LO message SERVICE VENT MON appears in the Alarm window. If this happens, contact an authorized representative of DrägerService.

## Problem Resolution

Table 12-1. Respiratory Volume Monitoring Problem Resolution

PROBLEM	POSSIBLE CAUSE	REMEDY
Blank display area, VOL SEN DISC alarm message in Alarm window	One full minute has not elapsed (for minute volume and respiratory rate) since respiration began	Wait one full minute to read display.
	Apnea condition	Correct apnea condition. Ensure sensor is properly connected to the expiratory valve.
	Sensor fault	Replace sensor assembly.
	Electronics housing is not properly seated on flow housing/transducer assembly	Reseat electronics housing on the flow housing/transducer assembly and ensure it is locked in place.
REVERSE FLOW alarm message in Alarm window	Expiratory valve not closing completely during inspiration	Check expiratory valve disc and pins. Clean, repair, or replace expiratory valve.
	Defective sensor	Replace sensor assembly.

# 13

## Breathing Pressure Monitoring

*This section describes the breathing pressure monitoring of the Narkomed MRI-2 anesthesia machine.*

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## Overview

Breathing pressure is measured with a solid-state pressure transducer that can sense pressure at either the absorber or patient Y-piece, depending on which pilot line is used.

## Choice of Breathing Pressure Monitoring Location

Draeger Medical has no control over the type of breathing hoses and Y-pieces that are ultimately used with Draeger Medical absorber systems and pressure monitors—specifically, whether such user-supplied components include a terminal for pressure monitoring at or near the Y-piece. In order to ensure that some form of pressure monitoring is always used, provisions have been made for pressure monitoring at the absorber (the quick-connect fitting on the absorber gas pipe). However, do not construe this provision for monitoring at the absorber as a recommendation from Draeger Medical for this pressure monitoring location.

In fact, arguments can be made for pressure monitoring at either the Y-piece or at the absorber. Advocates of Y-piece pressure monitoring first claim that it more accurately reflects the pressure developed in the patient's lungs. They also claim that a blocked breathing system can be more easily detected with this method when compared with pressure monitoring at the absorber.

For example, if the inspiratory breathing hose became kinked or blocked during automatic ventilation, the ventilator bellows would continue to cycle against the blocked hose. A pressure monitor connected at the Y-piece (downstream of the occlusion) could sense either an absence of pressure fluctuation and alarm, or could sense a reduced pressure fluctuation (below the threshold pressure alarm limit) and alarm. In contrast, a pressure monitor connected at the absorber (upstream of the occlusion) could sense a pressure fluctuation above the threshold pressure alarm limit, and thus would not alarm. (Both of these scenarios assume that the occlusion does not cause a peak pressure high enough to activate the peak pressure alarm, which is meant to detect pressures likely to cause barotrauma.)

However, Draeger Medical disagrees with the idea of relying on pressure monitoring to detect a blocked breathing circuit. Carbon dioxide monitoring and respiratory flow monitoring provide superior detection of blocked breathing paths when compared to pressure monitoring, which detects such conditions only in some instances. Draeger Medical pressure monitors are therefore not promoted for detection of blocked breathing paths.

Further, Y-piece pressure monitoring has several disadvantages that could collectively cause the operator to neglect connecting the pressure monitoring pilot line. Examples include increased contamination of the pilot line due to its proximity to secretions, buildup of condensation within the pilot line, and the introduction of additional disconnection points (if the pilot line connects to a 15 mm adapter).

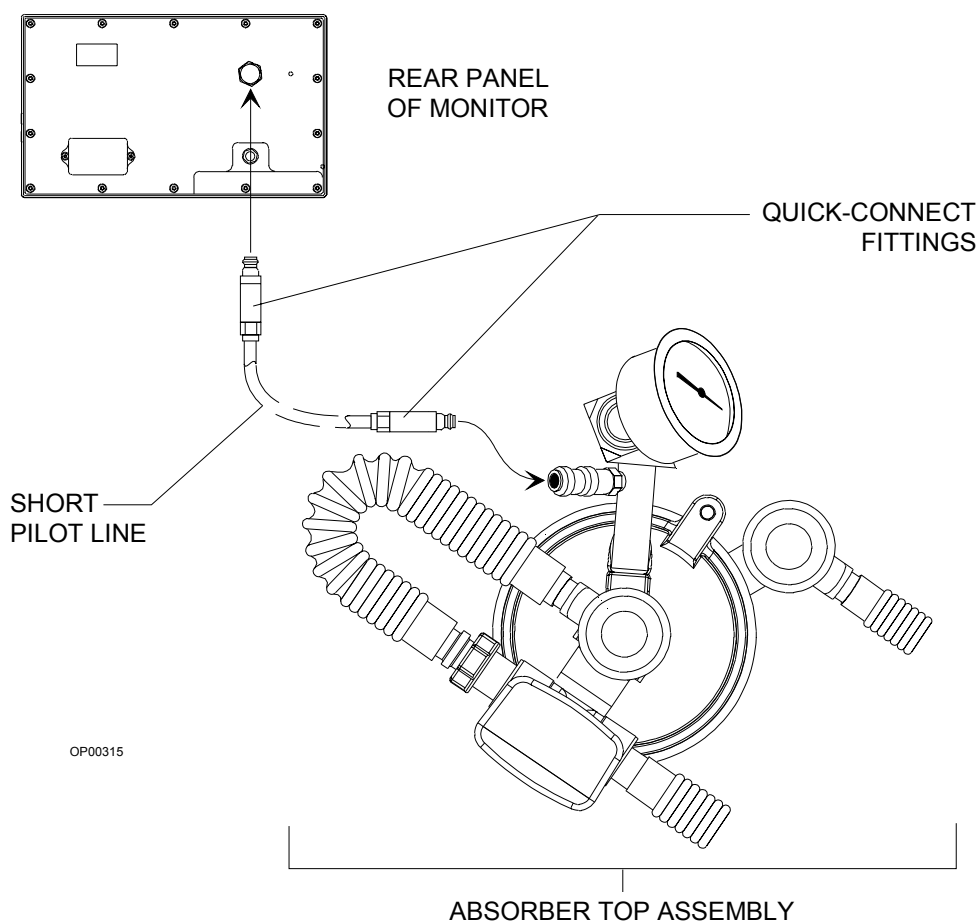
In conclusion, the responsibility for the selection of pressure monitoring at either the absorber or the Y-piece rests with you, the operator. Your clinical considerations, over which Draeger Medical has no control, must be included in this decision. Draeger Medical is available to discuss with you in detail the positive and negative aspects of each pressure monitoring approach.

## Installing the Breathing Pressure Pilot Line

For breathing pressure monitoring at the absorber, install the short pilot line (which has quick-connect fittings on both ends) as follows (refer to Figure 13-1):

1. Connect one end of the pilot line to the fitting mounted on the rear of the pipe extending from the absorber top assembly.
2. Connect the other end of the pilot line to the BREATHING PRESSURE interface on the rear of the ventilator monitor.

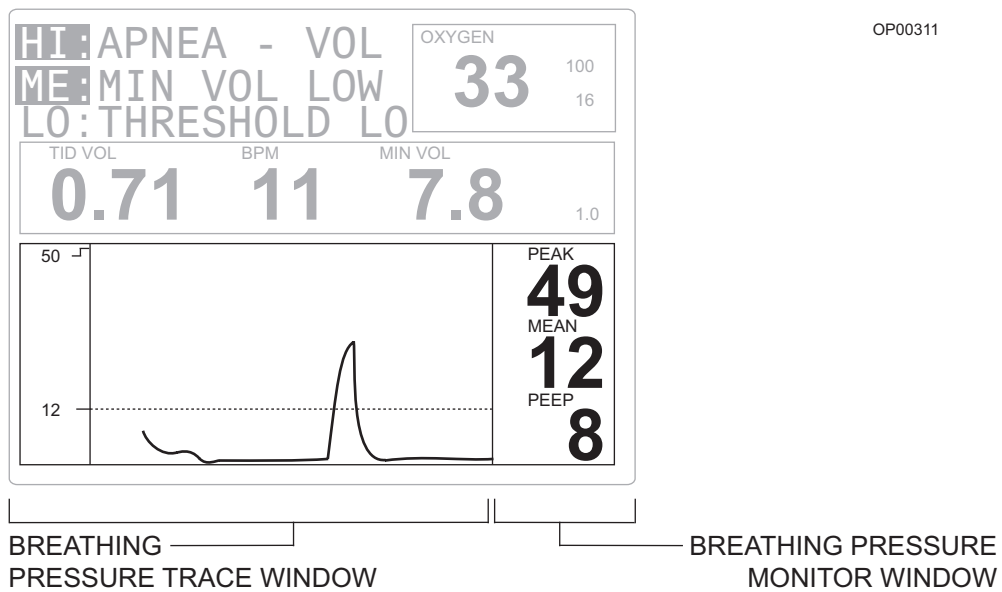
**Figure 13-1. Absorber Monitoring**



## Monitor Displays

Information about the patient's breathing pressure is presented in two windows at the bottom of the monitor display as shown in Figure 13-2.

Figure 13-2. Monitor Displays

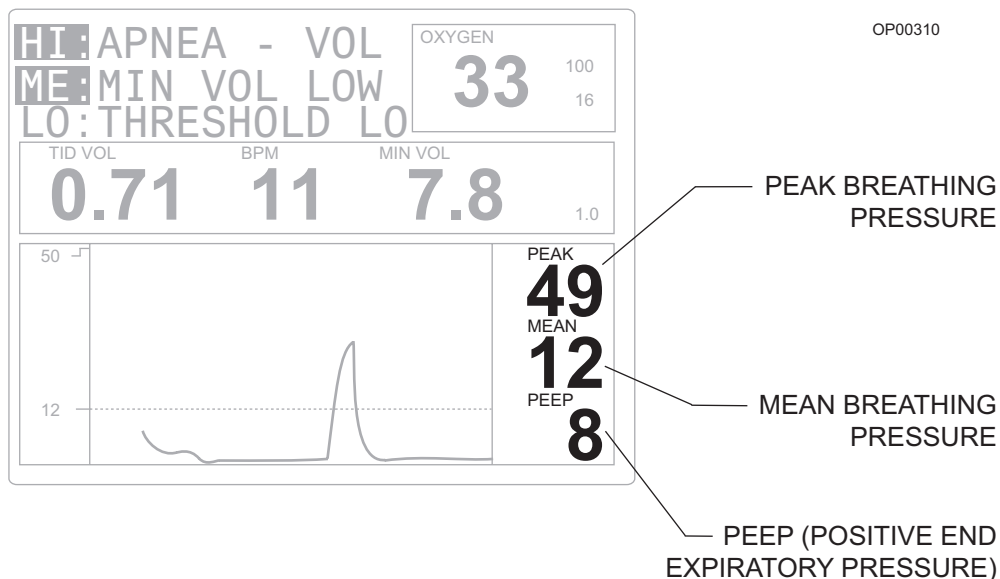


- **Breathing Pressure Trace Window**—This large window on the left displays a breathing pressure trace, or waveform. To the left of the waveform, in small type, are the pressure high and threshold pressure alarm limits.
- **Breathing Pressure Monitor Window**—This small window on the right contains numerical breathing pressure measurements.

### Breathing Pressure Monitor Window

The Breathing Pressure Monitor window, shown in Figure 13-3, contains breathing pressure measurements expressed in units of cm H<sub>2</sub>O.

Figure 13-3. Breathing Pressure Monitor Window



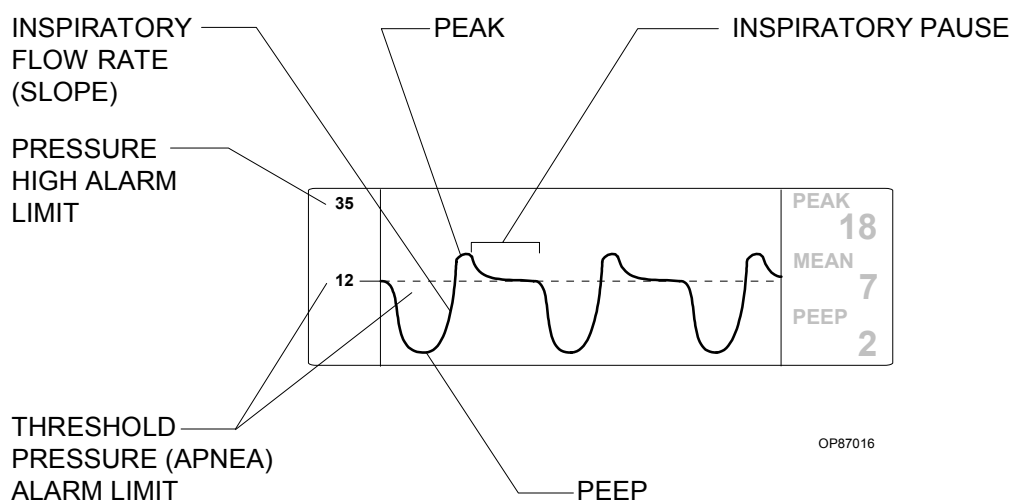
- **PEAK Breathing Pressure**—The highest instantaneous pressure value for each breath
- **MEAN Breathing Pressure**—The average of all the instantaneous pressure values recorded during each breath
- **PEEP (Positive End Expiratory Pressure)**—The breathing pressure at the end of exhalation

During apneic conditions, the pressure monitor displays numeric information as long as it detects a peak pressure at least 10 cm H<sub>2</sub>O greater than PEEP pressure. When this pressure difference drops below 10 cm H<sub>2</sub>O, the numeric information remains 1 minute longer and then disappears.

## Breathing Pressure Trace Window

The Breathing Pressure Trace window displays the breathing pressure waveform, and the pressure high and threshold pressure alarm limits. Pressure measurements are displayed in units of cm H<sub>2</sub>O and are automatically scaled from 0–20, 0–50, or 0–100 cm H<sub>2</sub>O. If the scale changes, the positions of the waveform and alarm limits also change relative to the new scale. The window shown below in Figure 13-4 has a scale of 0–20 cm H<sub>2</sub>O.

Figure 13-4. Breathing Pressure Trace Window

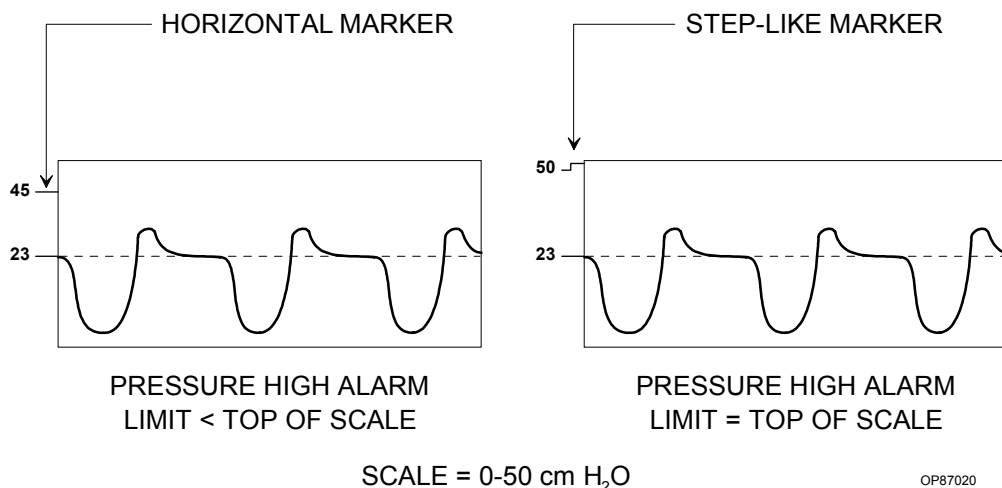


- The peak of the waveform corresponds to the peak pressure.
- The slope of the trace as it rises toward the peak pressure is correlated with the inspiratory flow rate; the steeper the slope, the higher the flow rate.
- The amount of pressure that the baseline is raised from zero corresponds to the patient's positive end expiratory pressure (PEEP).
- The length of the plateau from peak pressure to the decrease in pressure corresponding to expiration is equivalent to the length of the inspiratory pause (if present).

- The horizontal dotted line on the waveform and the adjacent marker on the Y-axis both represent the threshold pressure (apnea) alarm limit. The horizontal dotted line is always displayed, but the marker on the Y-axis appears only when the threshold pressure alarm limit is less than or equal to the top of the scale set by the system. There is a marker in the illustration above, because the threshold pressure alarm limit (12 cm H<sub>2</sub>O) is less than the top of the scale (20 cm H<sub>2</sub>O).
- The pressure high alarm limit is denoted by a marker on the Y-axis only when it is less than or equal to the top of the scale set by the system. In Figure 13-4, the pressure high alarm limit (35 cm H<sub>2</sub>O) is greater than the top of the scale (20 cm H<sub>2</sub>O).

When a high alarm limit marker is displayed, its appearance depends on whether the pressure high alarm limit is less than or equal to the top of the scale. Figure 13-5 illustrates the difference in appearance. (Note that a threshold pressure alarm limit marker is also displayed in these examples.)

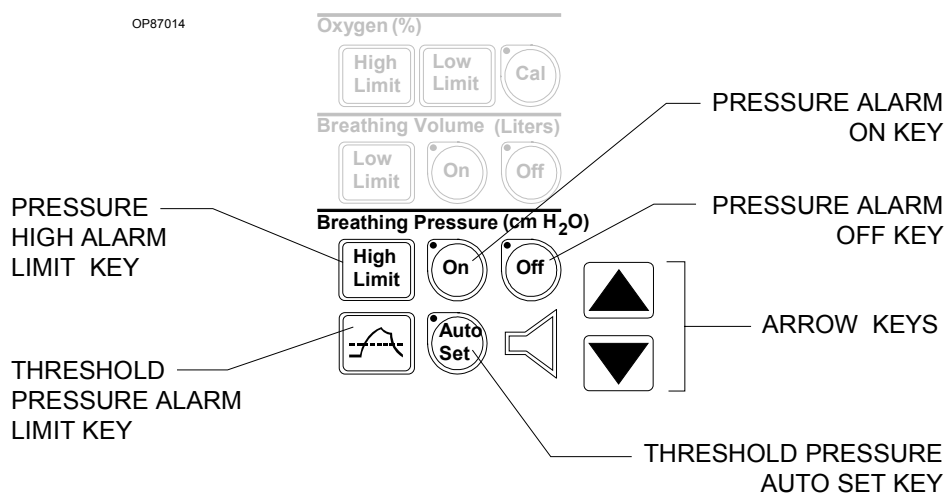
**Figure 13-5. Breathing Pressure Trace Window with Examples of High Alarm Limit Markers**



## Monitor Controls

You use the breathing pressure monitor control keys to set breathing pressure alarm limits, turn the apnea (threshold pressure) alarm off or on, and automatically set the threshold pressure. The breathing pressure monitor control keys are located next to the Breathing Pressure Monitor window. See Figure 13-6.

Figure 13-6. Monitor Controls



## Setting the Pressure High Alarm Limit

The pressure high alarm limit is automatically set to 50 cm H<sub>2</sub>O at power-up. You can change this limit to any value from 30–120 cm H<sub>2</sub>O, as long as it is greater than the threshold pressure alarm limit.



To adjust the pressure high alarm limit, follow these steps:

1. Press the Breathing Pressure High Limit key.  
A box is drawn around the pressure high alarm limit.
2. Press the up arrow or down arrow key to increase or decrease the pressure high alarm limit.
3. To save the new value, stop pressing arrow keys until the highlighting box disappears (5 seconds), or press a different Alarm Limit key.

The new value is saved and displayed as the pressure high alarm limit. If the alarm limit is on or below the upper limit of the scale, a marker appears next to the alarm limit.

## Setting the Threshold Pressure Alarm Limit

The threshold pressure alarm limit defines the level below which an apneic alarm condition exists. When the patient's breathing pressure falls below the threshold limit, a message appears in the Alarm window and an audible alarm sounds.

The threshold pressure alarm limit is automatically set to 12 cm H<sub>2</sub>O at power-up. The setting can be changed to any value from 5–30 cm H<sub>2</sub>O, as long as it is less than the pressure high alarm limit. You can change the alarm limit manually to a value you select or have the system set it automatically to an optimum value based on the current peak pressure.

**WARNING:** The threshold pressure alarm limit should be as close as possible to the sensed peak pressure without exceeding it. For details, see “Threshold Limit Guidelines” and “Sample Threshold Limit Settings” in this section.

### Manually Setting the Threshold Limit



To set the threshold pressure alarm limit manually, follow these steps. Remember that the value must be within the range of 5–30 cm H<sub>2</sub>O and less than the pressure high alarm limit.

1. Press the Breathing Pressure Threshold key.  
A box is drawn around the threshold pressure alarm limit.
2. Press the up arrow or down arrow key to increase or decrease the threshold pressure alarm limit.
3. To save the new value, stop pressing arrow keys until the highlighting box disappears (5 seconds), or press a different Alarm Limit key.

The new value is saved and displayed as the threshold pressure alarm limit. If the alarm limit is on or below the upper limit of the scale, a marker appears next to the alarm limit, and a dotted line extends from the alarm limit horizontally across the scale.

### Automatically Setting the Threshold Limit



You can have the monitoring system automatically set the threshold pressure alarm limit to an optimum value based on the current peak pressure.

To automatically set the threshold pressure alarm limit, press and then release the Breathing Pressure Auto Set key.

The LED next to the Breathing Pressure Auto Set key lights briefly when you press it.

The threshold pressure limit is automatically set 4 cm H<sub>2</sub>O below the current peak pressure measurement, to a minimum of 5 cm H<sub>2</sub>O and a maximum of 30 cm H<sub>2</sub>O.

### Threshold Limit Guidelines

If the alarm limit is on or below the upper limit of the scale, a marker appears next to the alarm limit, and a dotted line extends from the alarm limit horizontally across the scale.

If a breathing system leak or partial disconnection occurs when the threshold pressure alarm limit is set significantly lower than the peak pressure, continued positive pressure ventilation can produce a pressure fluctuation great enough to exceed the threshold (and thereby satisfy the alarm), yet not great enough to provide adequate ventilation.

To address the problem, the LO message THRESHOLD LO appears in the Alarm window when either of the following conditions occurs:

- The sensed peak pressure exceeds the set threshold by more than 6 cm H<sub>2</sub>O at threshold pressure alarm limit settings of 5–20 cm H<sub>2</sub>O.
- The sensed peak pressure exceeds the set threshold by more than 8 cm H<sub>2</sub>O at threshold pressure alarm limit settings of 21–29 cm H<sub>2</sub>O.

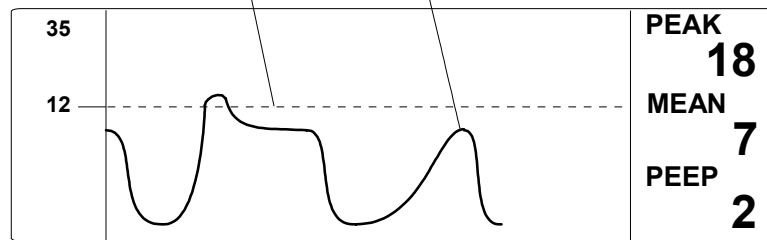
**NOTE:** The threshold setting may be affected when the ventilator is turned on or off. If you turn the ventilator off while the threshold is set to a value greater than 15 cm H<sub>2</sub>O, the setting is changed to 15 cm H<sub>2</sub>O. (If the threshold is set lower than 15 cm H<sub>2</sub>O when the ventilator is turned off, the threshold retains its setting.) When the ventilator is turned back on, the threshold is restored to its previous set value.

### Sample Threshold Limit Settings

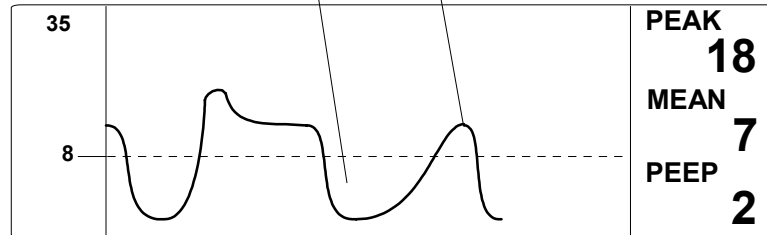
Figure 13-7 illustrates the effects of correct and incorrect settings of the threshold pressure alarm limit.

**Figure 13-7. Sample Threshold Limit Settings**

1. Threshold pressure alarm limit correctly set to within 6 cm H<sub>2</sub>O of peak pressure (for alarm limit settings of 5 through 20 cm H<sub>2</sub>O).
2. Thus, after partial breathing system disconnection or leak, small pressure fluctuation does not cross threshold pressure alarm limit. Operator is warned of apnea condition.



1. Threshold pressure alarm limit incorrectly set > 6 cm H<sub>2</sub>O below peak pressure.
2. Thus, after partial breathing system disconnection or leak, small pressure fluctuation in system satisfies incorrectly set threshold pressure alarm limit. Operator is not alerted of apnea condition.



OP87018

## Turning the Apnea Pressure Alarm Off

You can turn the apnea pressure alarm off only when the ventilator is off. When the ventilator is on, the alarm is automatically forced on to ensure notification of problem conditions.



To turn off the apnea pressure alarm, press the Breathing Pressure Off key. Audio annunciation of the alarm is disabled and pressure alarm messages are erased from the display. The LED next to the Breathing Pressure Off key lights to indicate that the apnea pressure alarm is disabled.

## Turning the Apnea Pressure Alarm On

To turn on the apnea pressure alarm, press the Breathing Pressure On key.



The LED next to the Breathing Pressure On key lights to indicate that the apnea pressure alarm is enabled.

**NOTE:** After power-up, the pressure alarms are in the standby state.

## Breathing Pressure Alarm Messages

The following list contains all HI, ME and LO alarms associated with breathing pressure monitoring.

### APNEA- PRESSURE (HI/ME)

#### When the ventilator is on:

If the measured breathing pressure remains below the threshold pressure alarm limit for more than 15 seconds, the ME message APNEA-PRES appears in the Alarm window and an intermittent audible alarm sounds.

If the breathing pressure remains below the threshold pressure for an additional 15 seconds (30 seconds total), the ME message APNEA-PRES is upgraded to a HI message in the Alarm window, and a continuously repeating audible alarm sounds. During the HI condition, numeric data remains on the display as long as the monitor detects a peak pressure at least 10 cm H<sub>2</sub>O greater than PEEP pressure. When this pressure difference drops and remains below 10 cm H<sub>2</sub>O for more than 60 seconds, the numeric data is cleared.

#### When the ventilator is off:

The ME condition does not occur until 30 seconds have elapsed; the HI condition does not occur until 60 seconds have elapsed.

<b>APNEA-P ALM STBY (LO)</b>	Any time that the apnea pressure alarm (threshold pressure alarm limit) has been set to Standby, the LO message APNEA-P ALM STBY appears in the Alarm window.
<b>BR PRS ERR (LO)</b>	If the Narkomed MRI-2 detects an internal electronic failure that would prevent proper operation, the LO message BR PRS ERR appears in the Alarm window. If this happens, contact an authorized representative of DrägerService.
<b>CONTNG PRES (HI)</b>	<p>If the measured breathing pressure remains above the threshold pressure alarm limit for more than 15 seconds, the breathing pressure display area is cleared, the HI message CONTNG PRES appears in the Alarm window, and an intermittent audible alarm sounds.</p> <p>When the measured breathing pressure drops below the threshold pressure alarm limit, alarm annunciation ceases.</p>
<b>O2 MON ERR (LO)</b>	If the Narkomed MRI-2 detects an internal electronic failure that would prevent proper operation, the LO message O2 MON ERR appears in the Alarm window. If this happens, contact an authorized representative of DrägerService.
<b>PEEP &gt; 4 (LO)</b>	<p>Any time the monitor measures a PEEP of 5 cm H<sub>2</sub>O or greater, the LO message PEEP &gt; 4 appears in the Alarm window.</p> <p>When the measured PEEP drops below 5 cm H<sub>2</sub>O, the LO message is cleared from the display.</p>
<b>PEEP &gt; 25 (ME)</b>	<p>Any time that the monitor measures a PEEP of 26 cm H<sub>2</sub>O or greater, the ME message PEEP &gt; 25 appears in the Alarm window and an intermittent audible alarm sounds.</p> <p>Alarm annunciation ceases when the measured PEEP drops below 26 cm H<sub>2</sub>O. Also, an APNEA or CONTNG PRES alarm condition will clear this alarm condition.</p>
<b>SUB ATM PRES (HI)</b>	<p>If the measured breathing pressure falls below -10 cm H<sub>2</sub>O, the HI message SUB ATM PRES appears in the Alarm window and a continuously repeating audible alarm sounds.</p> <p>This alarm condition is cleared when the sensed pressure rises above -10 cm H<sub>2</sub>O. However, the alarm message is extended for 5 seconds to allow the recognition of a momentary subatmospheric pressure condition.</p>

**THRESHOLD  
LO (LO)**

The LO message THRESHOLD LO appears in the Alarm window any time the sensed peak pressure exceeds the threshold pressure alarm limit by more than 6 cm H<sub>2</sub>O at threshold pressure alarm limit settings of 5–20 cm H<sub>2</sub>O, or by more than 8 cm H<sub>2</sub>O at threshold pressure alarm limit settings of 21–29 cm H<sub>2</sub>O. Setting the threshold pressure alarm limit at 30 cm H<sub>2</sub>O disables the THRESHOLD LO alert.

**VENT PRES  
HI (HI)**

If the measured breathing pressure exceeds the high pressure limit, the HI message VENT PRES HI appears in the Alarm window and a continuously repeating audible alarm sounds.

This alarm condition is cleared when the measured breathing pressure drops below the high pressure alarm limit. However, the alarm message is extended for 5 seconds to allow for a momentary high pressure condition.

**Problem Resolution**

**Table 13-1. Breathing Pressure Monitoring Problem Resolution**

PROBLEM	POSSIBLE CAUSE	REMEDY
No pressure readout in display area during ventilation	Pilot line not connected	Make sure pilot line is properly connected.
	Pilot line blocked or kinked	Make sure that lumen of pilot line is free of obstructions.
Erratic readings	Condensation accumulation in pilot line	Drain and reconnect pilot line.

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# 14

## Routine Maintenance and Cleaning

*This section describes routine maintenance and cleaning for the Narkomed MRI-2 anesthesia machine.*

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## Overview

This section outlines procedures for maintaining and cleaning the Narkomed MRI-2.

**WARNING:** Do not place any object on this machine unless it is specifically labeled to be used in an MRI scanning room and on a Narkomed MRI-2 anesthesia system. Objects placed on this machine that are not designed for use with this anesthesia system may be strongly attracted to the magnet and may cause serious injury or death when the machine is used in an MRI scanning room.

## Routine Maintenance

Routine maintenance must be performed regularly to ensure safe and effective operation. Regularly check the condition of the absorbent and the overall condition of the machine, power cord, hoses, and breathing bag.

### Replacing the Absorbent

When the carbon dioxide absorbent in the absorber system is exhausted, it must be replaced. Refer to the manufacturer's instructions for the signs to expect when the absorbent is exhausted.

If the machine has been out of use or in storage, replace the absorbent before using the machine. Draeger Medical recommends establishing a routine schedule with a sufficient safety margin for replacing absorbent.

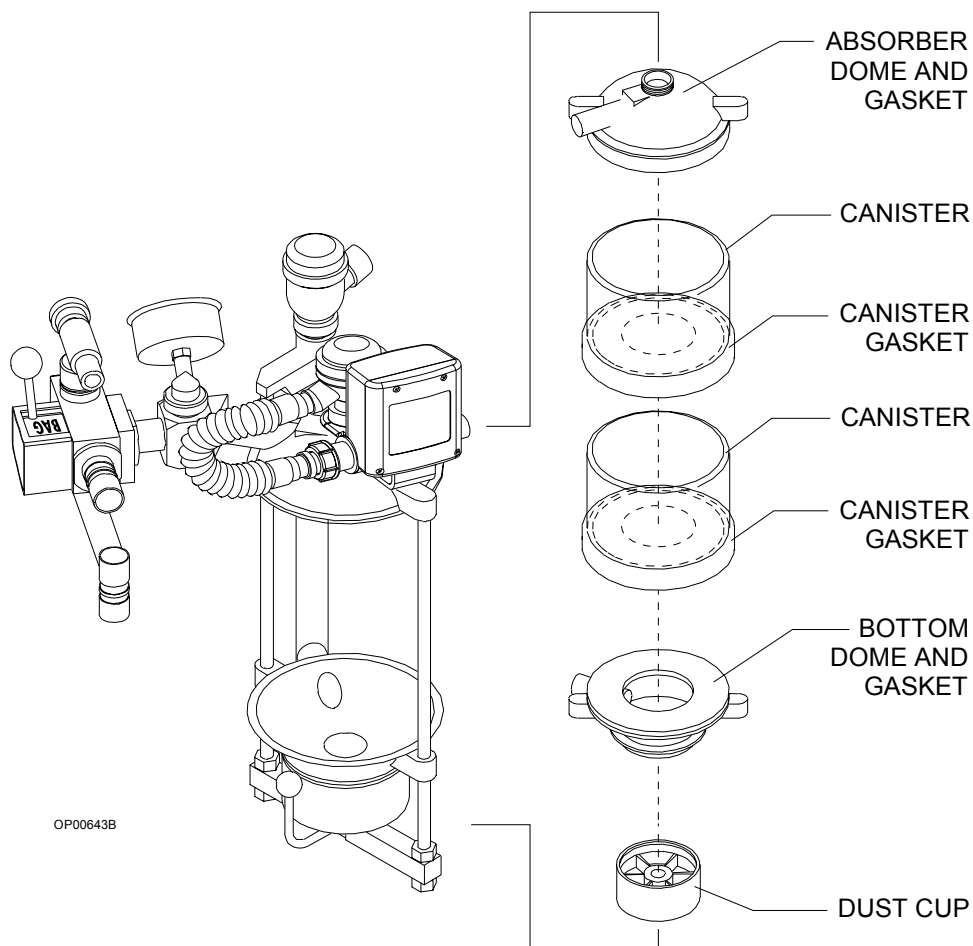
When using loose absorbent, do not fill above the maximum fill level line located about a quarter-inch from the top of the canister. The clearance and the ratio of canister diameter to screen opening minimize the potential for channeling. In channeling, gas flows through the canister along the path of least resistance. The gas depletes the efficiency of the absorbent along this route, bypassing absorbent in the other areas of the absorber.

**WARNING:** Absorbent is caustic and is a strong irritant to the eyes, skin, and respiratory tract. When replacing the absorbent, take care not to spill its caustic contents.

To replace the absorbent:

1. Pull the canister release lever down.
2. Remove the canisters from the absorber system.
3. Empty the contents of the canisters into an appropriate refuse container.
4. Check the canisters to make sure they are not chipped or cracked.

Figure 14-1. Replacing the Absorbent



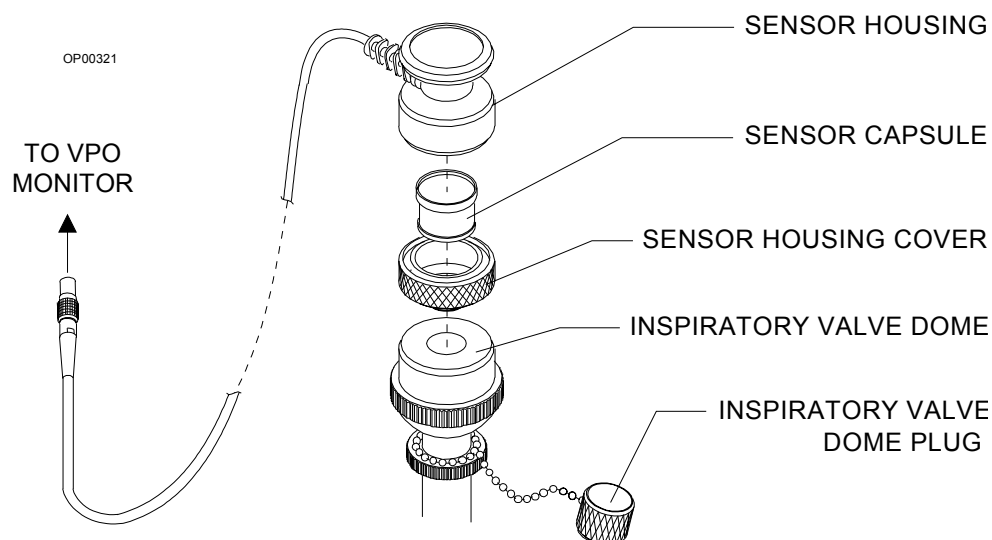
5. Taking care not to chip or crack the canisters, add new absorbent to each one.
  - When using absorbent prepacks, remove all packaging materials (some have clear plastic wrappers) and place a prepack into each canister.
  - When using loose absorbent, fill the canister to the fill line. Do not overfill.
6. Stack one canister on top of the other and center the stack on the gasket of the bottom dome.
7. Raise the bottom dome, remove and empty the dust cup if loose absorbent is present, and replace the dust cup.
8. Pull the canister release lever up to close the absorber system.
9. Perform the absorber portion of the daily checkout procedure provided in the “Daily Checkout” section to verify proper reassembly.

### Replacing the Oxygen Sensor

Replace the oxygen sensor capsule when its sensor is depleted, because a depleted sensor cannot correctly analyze oxygen concentrations.

1. Turn the SYSTEM POWER switch to STANDBY.
2. Pull the oxygen sensor housing from the inspiratory valve dome. (It is a press fit.)
3. Unscrew the cover from the sensor housing and remove the sensor capsule.

Figure 14-2. Replacing the Oxygen Sensor



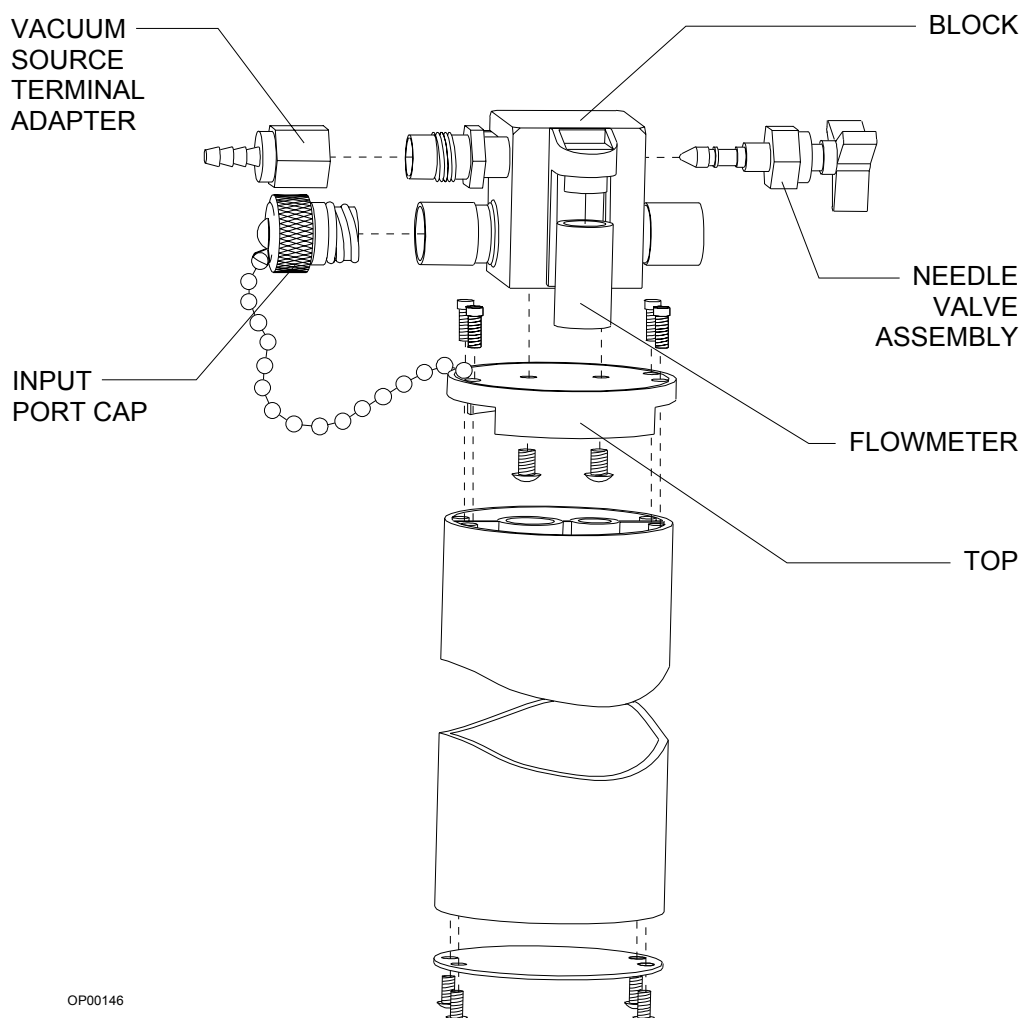
4. Remove the replacement sensor capsule from its shipping container and install it in the housing. Ensure that the copper rings on the capsule mate with the electrical contacts in the sensor housing.
5. Wait 15 minutes to allow the sensor capsule to stabilize.
6. Restore power to the machine and perform an oxygen sensor calibration as described in "Calibrating the Oxygen Sensor" on page 11-4.

## Open Reservoir Scavenger Maintenance

The scavenger should be cleaned at least once every six months.

1. Clean the outer surface of the scavenger with a soft cloth moistened with mild detergent and water.
2. Remove and inspect all scavenger hoses for signs of deterioration. Replace any worn hoses.
3. If applicable, unscrew the wing nut until the needle valve assembly can be removed from its seat. Remove the nut and disassemble the valve. Inspect the needle valve and seat for lint or dust accumulation. Clean with compressed air, if necessary.

Figure 14-3. Open Reservoir Scavenger Maintenance



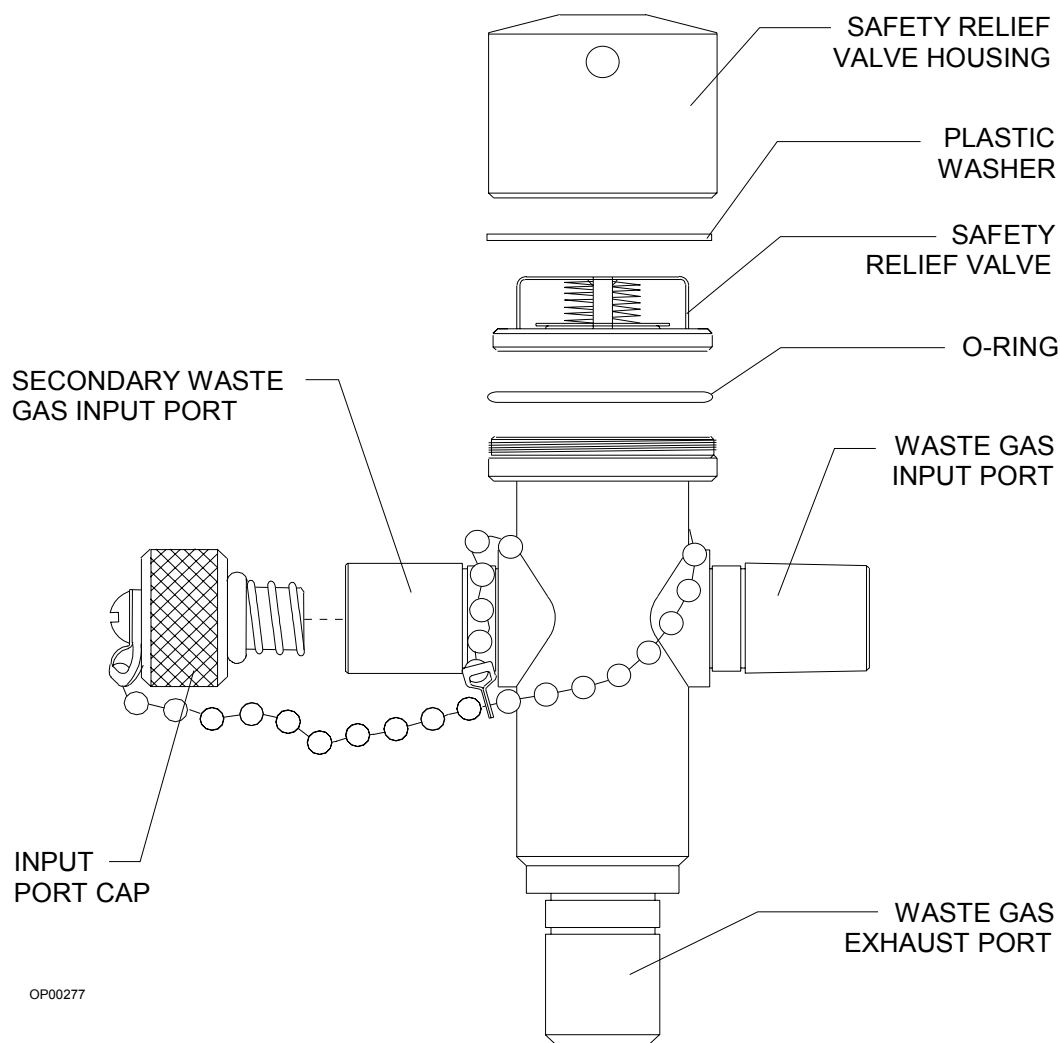
4. The flowmeter has a small port, located on its underside, that is open to the atmosphere. For the flowmeter to work properly, this port must remain open. Remove the flowmeter from the block and inspect this port. If it is blocked, clean it with compressed air.
5. Remove the reservoir canister from the scavenger body by unscrewing the four socket head cap screws located at the top of the canister.
6. Replace the cleaned needle valve assembly and reservoir canister. Verify that all parts are completely dry before reassembly.
7. Perform the open reservoir scavenger portion of the daily checkout procedure provided in "Daily Checkout."

**Scavenger  
Interface for  
Passive  
Systems  
Maintenance**

The scavenger should be cleaned at least once every six months.

1. Clean the scavenger body with a moist cloth.
2. Inspect all scavenger hoses for deterioration. Replace any worn hoses.
3. Remove the relief valve housing by unscrewing it counterclockwise.
4. Inspect the rubber o-ring. If it is worn, replace it.
5. Remove the relief valve by twisting it counterclockwise out of the housing. You can use the tips of a needle-nose pliers to turn the valve, but take care not to damage the relief valve's fragile valve disk.
6. Brush any accumulated lint or dust off the valve with a soft brush. The valve can be further cleaned with a low flow of clean air or oxygen.
7. Reinstall the valve into the housing, making sure that it is threaded all the way into the housing and that the plastic washer is properly seated on its upper surface.
8. Verify that the interior of the valve body is completely dry. Reinstall the valve housing onto the scavenger body, making sure that the o-ring is properly seated.
9. Perform the scavenger interface for passive systems portion of the daily checkout procedure provided in "Daily Checkout."

Figure 14-4. Scavenger Interface for Passive Systems Maintenance



### Tracheal Suction System Maintenance

For information on tracheal suction system maintenance, see the manufacturer's instructions supplied with the suction system assembly.

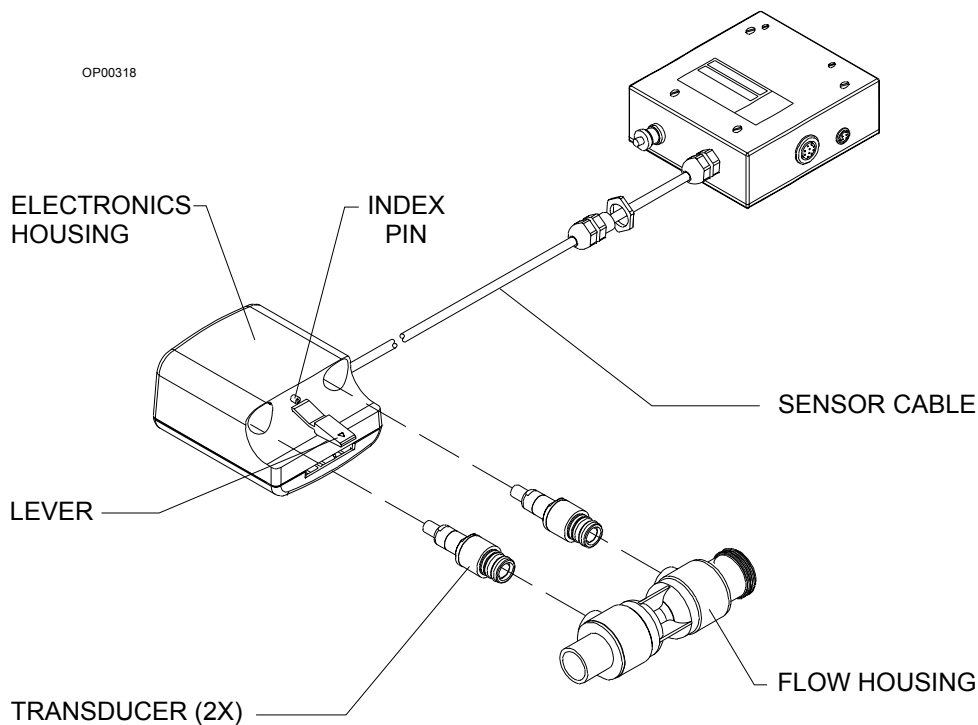
### Clearing Condensation in the Ultrasonic Flow Sensor

Depending on the conditions of use and the environment, condensation can accumulate in the flow sensor housing. Moderate amounts of condensation should not affect operation. Excessive condensation can result in erratic measurements or total loss of flow measurement.

To remove condensation:

1. Remove the connector hose assembly between the flow sensor and expiratory valve by turning the ring nut counterclockwise.
2. Remove the patient hose from the expiratory hose terminal on the flow sensor.
3. Lift the flow sensor off the bracket.
4. Press down on the lever under the flow housing and remove the flow housing/transducer assembly from the electronics housing.
5. Pull both transducers out of the flow housing.

Figure 14-5. Clearing Condensation in the Ultrasonic Flow Sensor



6. Tip and shake the flow housing to release fluid trapped in the housing.
7. Make sure that all large droplets are cleared from the transducer ports.
8. Pat the transducers dry with a soft, lint-free cloth.
9. Press the transducers back into their ports in the flow housing.

10. Slide the electronics housing over the flow housing/transducer assembly. Be sure that it clicks into place.

**NOTE:** If the flow housing/transducer assembly does not fit easily into the electronics housing, make sure the flow housing is facing the right direction. Compare the direction to the illustration on the electronics housing. The index pin on the electronics housing should align with the hole in the flow housing.

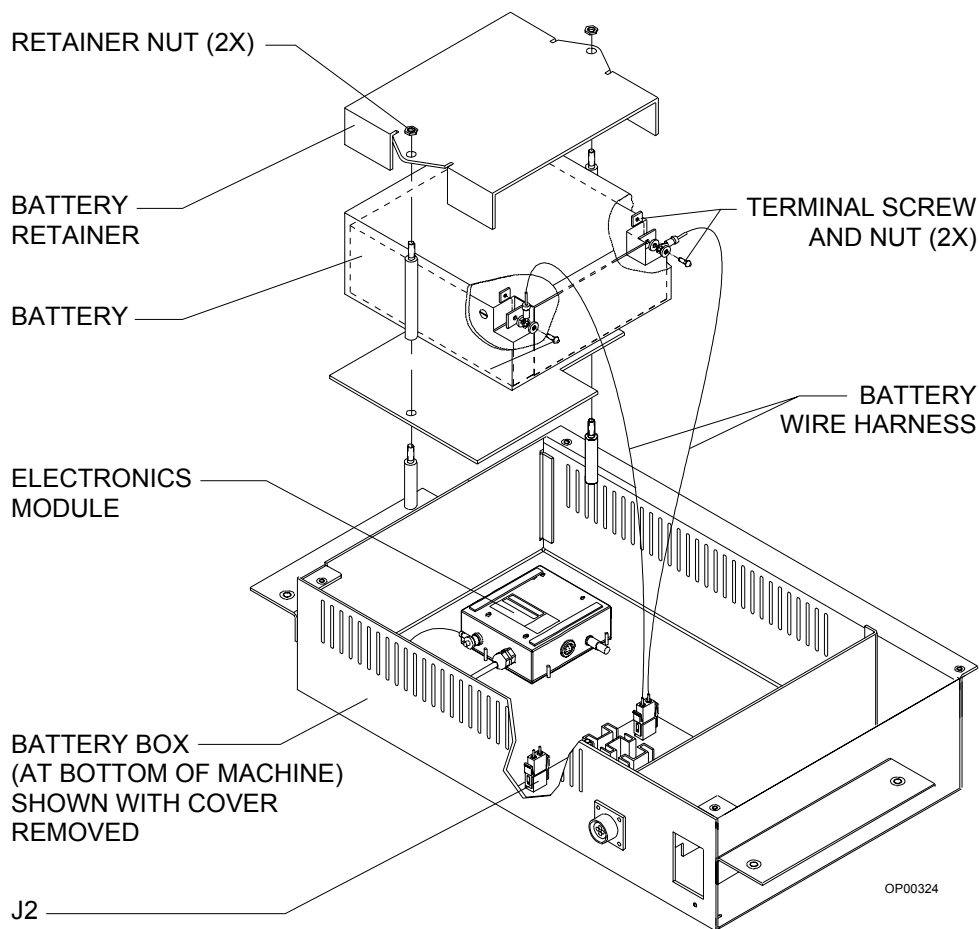
11. Slide the flow sensor onto the bracket.
12. Connect the patient hose to the expiratory hose terminal on the flow sensor.
13. Install the connector hose assembly between the flow sensor and the expiratory valve, and secure it by turning the ring nut clockwise.

## Battery Maintenance

The backup battery is located in the battery box at the bottom of the machine. Access to the battery requires removal of the battery box cover.

1. Turn the System Power switch to STANDBY and remove the power cable from the back of the battery box.
2. Remove the top cover from the battery box.
3. Disconnect the battery wire harness from J2 on the PCB.
4. Remove the two retainer nuts, and remove the battery retainer.
5. Remove the battery from the battery box.
6. If needed, transfer the wire harness to the replacement battery (yellow wire to (+) terminal, black wire to (-) terminal) and ensure that the replacement battery is wrapped in a protective bag in the same manner as the original.
7. Place the replacement battery in the battery box, oriented as shown in the illustration.
8. Record the installation date on the battery.
9. Reinstall the battery retainer and the two retainer nuts.

Figure 14-6. Battery Maintenance



10. Reconnect the battery wire harness to J2 on the PCB.
11. Reinstall the battery box top cover.
12. Reconnect the power cable to the connector on the back of the battery box.
13. Perform the PMS Procedure in the *Narkomed MRI-2 Setup and Installation Manual*.

### End of Life Battery Disposal

Dispose of a spent rechargeable, sealed lead acid battery in conformance with local waste disposal regulations.

## Removing Parts for Cleaning and Disinfection

1. Turn the SYSTEM POWER switch to STANDBY.
2. Disconnect the 22 mm breathing circuit hoses between the ventilator and the absorber and from the inspiratory valve and the expiratory hose terminal on the ultrasonic flow sensor. Remove the Y-piece, mask, and mask elbow from the hoses.
3. Disconnect the 19 mm scavenger hoses connecting the APL valve to the absorber pole and the ventilator relief valve to the scavenger.

**NOTE:** The scavenger interface generally does not need disinfection. However, if your facility requires a disinfection process for the scavenger interface and hoses, remove the scavenger and all 19 mm hoses. Refer back to the cleaning instructions under “Open Reservoir Scavenger Maintenance” or “Scavenger Interface for Passive Systems Maintenance” for disassembly instructions.

4. Remove the oxygen sensor assembly from the inspiratory valve, and disconnect the cable that connects the sensor to the monitor.
5. Remove the connector hose assembly between the flow sensor and the expiratory valve by turning the ring nut counterclockwise.
6. Lift the flow sensor off the bracket.
7. Disconnect the fresh gas hose from the fresh gas outlet.
8. Disconnect the breathing pressure pilot line from the absorber and the monitor.
9. Remove the absorbent canisters and dust cup. Discard the absorbent. Refer back to “Replacing the Absorbent” for instructions.

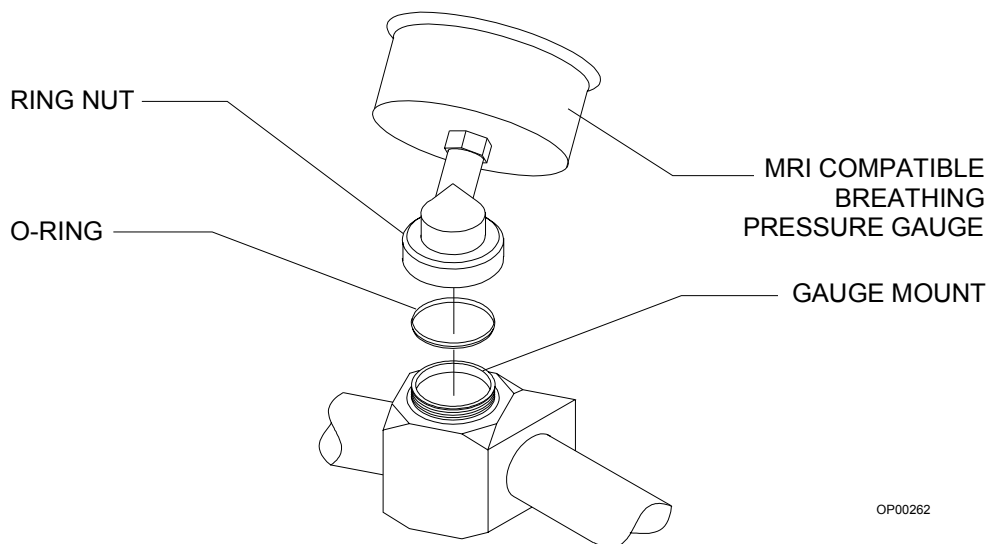
**WARNING:** Absorbent is caustic and a strong irritant to the eyes, skin, and respiratory tract. When removing the absorbent, take care not to spill its caustic contents.

10. Remove the inspiratory and expiratory valves by turning their ring nuts counterclockwise until they are free of the system.
11. Remove the ultrasonic flow sensor by turning its ring nut counterclockwise until it is free of the absorber dome.
12. Remove the pressure gauge by turning the knurled ring nut that connects the pressure gauge to the gauge mount counterclockwise. Lift the pressure gauge assembly off the gauge mount. Do not misplace the o-ring.

**CAUTION:** Only the pressure gauge supplied with a Narkomed MRI-2 should be used.

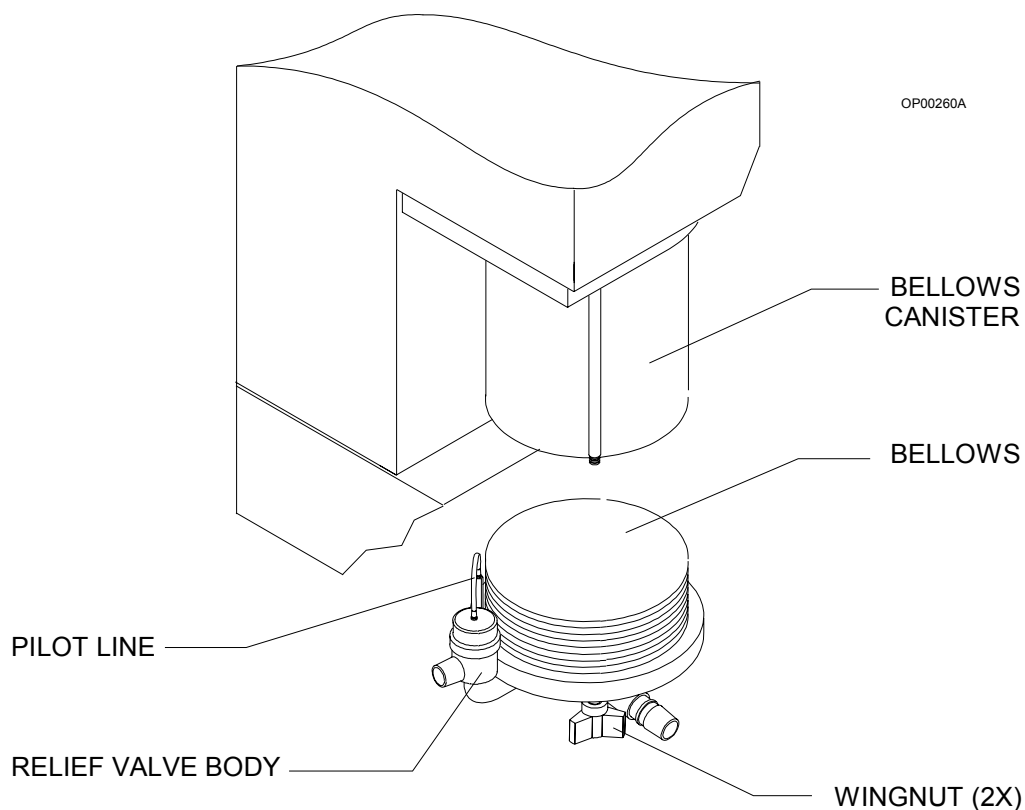
**WARNING:** Use manufacturer authorized replacement parts only. Failure to do so may result in machine malfunction, injury, or death.

**Figure 14-7. Removing Parts for Cleaning and Disinfection (1)**



13. Remove the absorber using a 3/16-inch hex screwdriver to loosen the hex screw securing the absorber assembly to the absorber pole. Do not remove the screw. Lift the absorber off the absorber pole. Do not misplace the o-ring.
14. Remove the bellows assembly by loosening the two wing nuts on the bottom of the assembly until the assembly releases from the canister.

Figure 14-8. Removing Parts for Cleaning and Disinfection (2)



## Disassembling Parts for Cleaning and Disinfection

The following parts must be further disassembled for thorough cleaning and disinfection:

- oxygen sensor assembly
- respiratory sensor flow housing/transducer assembly
- ventilator bellows assembly
- inspiratory/expiratory valves

### Disassembling the Oxygen Sensor Assembly

Unscrew the cover from the sensor housing and remove the sensor capsule. Take care not to drop the sensor housed inside. The sensor is not connected to the housing.

**Disassembling the Flow Housing/Transducer Assembly**

1. Press down on the lever under the flow housing and pull the flow housing/transducer assembly out of the electronics housing.
2. Pull both transducers out of the flow housing.

**Disassembling the Ventilator Bellows Assembly**

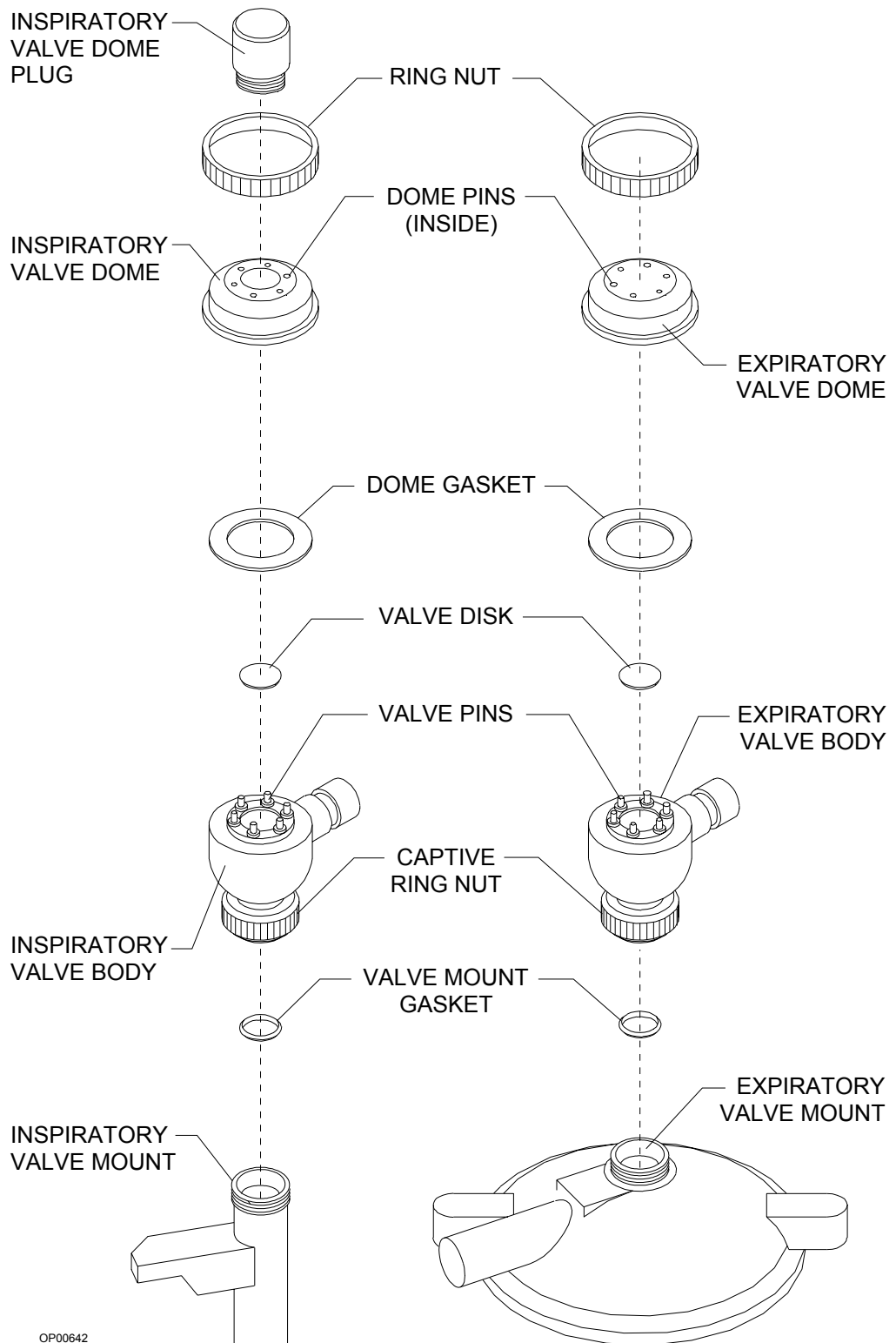
1. Remove the bellows from the ventilator bottom assembly by unscrewing it in a counterclockwise direction until it is released.
2. Unscrew the knurled ring nut around the ventilator relief valve and pull the relief valve dome and pilot line away from the relief valve body.

**CAUTION:** Take special care not to change the position of the adjustment lock ring on the ventilator relief valve dome. Do not attempt to loosen the knurled relief valve ring nut by twisting the pilot line hose barb.

**Disassembling the Inspiratory and Expiratory Valves**

Unscrew and remove the ring nut around the plastic valve dome.  
Separate the plastic dome, dome gasket, and valve disk from the valve body.

Figure 14-9. Disassembling the Inspiratory and Expiratory Valves



## General Guidelines for Cleaning and Disinfection

The frequency, level, and need for disinfection of the Narkomed MRI-2 is determined by the user facility based on the conditions of use and hospital infection control policy. Draeger Medical recommends using disposable patient breathing circuits that can be replaced after single use.

If disinfection is required, first clean, dry, and then disinfect the Narkomed MRI-2 and its parts according to the guidelines provided in this chapter. Determining the need and frequency of cleaning or disinfecting any particular component is the responsibility of the user institution. These procedures should be performed according to procedures established by the user institution, following the specific instructions provided by the manufacturer of the equipment or agent used.

For additional information about infection control practice, refer to the *APIC Guideline for Selection and Use of Disinfectants*. This guideline was developed by the Association for Professionals in Infection Control and Epidemiology, Inc. and published in *AJIC* Vol. 24, No. 4 pp. 313-342, August 1996. The following table of recommended disinfection methods for the Narkomed-MRI-2 was adapted from the *APIC Guideline for Selection and Use of Disinfectants*.

**Table 14-1. General Guidelines for Cleaning and Disinfection**

Part	A	B	C	D	E	F
Exterior Painted, Plated, and Plastic Surfaces					x	x
Corrugated Breathing Hoses, Mask Elbow, and Breathing Bag	x	x	x	x		
Y-Piece and Mask		x	x	x		
Ventilator Bellows		x	x	x		
Ventilator Bellows Bottom Assembly		x				
Oxygen Sensor Capsule		x				
Oxygen Sensor Housing					x	x
Oxygen Sensor Housing Cover		x	x	x		
Inspiratory/Expiratory Valves	x	x	x	x		
Ultrasonic Flow Sensor Housing and Transducers	x					
Ultrasonic Flow Sensor Cable					x	x
Breathing System Pressure Gauge		x				
Breathing Pressure Pilot Line		x				
Absorber Canisters, Gaskets, and Dust Cup	x	x	x	x		
Vaporizer Exterior					x	x
Corrugated Scavenger Hoses (do not normally need disinfection)	x	x	x	x		
Open Reservoir Scavenger (does not normally need disinfection)		x			x	x
Passive Scavenger Interface (does not normally need disinfection)		x			x	x

- A Heat sterilization (autoclaving), including steam or hot air (use manufacturer's recommendations)
- B Ethylene oxide gas (use manufacturer's recommendations)
- C Glutaraldehyde-based formulations (2%)
- D Wet pasteurization at 70° C for 30 minutes after detergent cleaning
- E Sodium hypochlorite (5.2% household bleach) 1:500 dilution (100 ppm free chlorine)
- F Ethyl or isopropyl alcohol (70% to 90%)

**CAUTION:** To avoid damaging the Narkomed-MRI-2:

- Do not use Betadine®, Povodine®, Sagrotan®, Mucocit®, acetone, ketone, xylene, or anesthetic agents for cleaning.
- Dilute cleaning agents before use by strictly following the manufacturer's instructions.
- Do not use abrasives such as steel wool, liquid abrasives, or powder abrasives on the machine.
- Do not let any liquid enter the interior of the machine.
- Do not submerge any part of the system, unless specifically instructed to do so in this manual.
- Do not pour or spray liquid directly on the machine during cleaning. Always moisten a soft-lint free cloth with the appropriate cleanser before applying it to the machine.
- Wipe any spills and cleanser off the equipment surfaces immediately.

**Cleaning and  
Disinfecting  
Exterior  
Surfaces**

Clean painted, plated, and plastic surfaces with a soft lint-free cloth moistened with mild detergent and water. Follow up with a 70% to 90% diluted solution of ethyl or isopropyl alcohol or sodium hypochlorite (5.2% household bleach) at 1:500 dilution (100 ppm chlorine).

**NOTE:** Draeger Medical makes no claims about the efficacy of these agents or this method of cleaning for infection control. Consult your hospital's infection control officer or epidemiologist.

**Cleaning and  
Disinfecting  
Corrugated  
Breathing  
Hoses, Mask  
Elbow, and  
Bag**

Contact with oxygen, ether, mineral or vegetable oils, phenols, cresols, terpenes, hydrocarbon solvents, chlorinated hydrocarbons, esters, or oxidizing acids hastens the deterioration process for rubber goods.

Check the hoses, mask elbow, and breathing bag often for signs of deterioration, including swelling, tackiness, or cracking. Replace the affected parts when any of these conditions are evident.

Thoroughly clean rubber goods with mild alkali detergent and water before disinfecting them. Then, thoroughly rinse them with water to remove all detergent. To prevent water spots, use distilled or demineralized water. Avoid using hard-bristle brushes.

Manufacturers of rubber goods recommend that reusable rubber goods be soaked in a liquid disinfection agent. Always follow the agent manufacturer's instructions for use.

**CAUTION:** Disinfectants containing phenol or phenyl compounds destroy rubber goods. Latex and rubber goods treated with disinfectants having a quaternary ammonium base will be damaged if subsequently autoclaved.

Use 2% glutaraldehyde-based formulations for more than 20 minutes or wet pasteurization at 70° C for 30 minutes after detergent cleaning.

Thoroughly rinse the corrugated hoses, mask elbow, and breathing bag after contact with chemicals. Use sterilized water to prevent contamination by tap water organisms. Thoroughly dry rubber goods before returning them to service.

The corrugated hoses, mask elbow, and breathing bag can be autoclaved at 121° C. However, such temperatures accelerate the natural aging of rubber goods. Autoclaved rubber goods can also harden over time as a result of the loss of softeners. Exposure to ozone or ultraviolet light also accelerates the natural aging of rubber goods. Reusable rubber goods can also be gas sterilized with ethylene oxide. After EtO sterilization, properly aerate rubber goods before returning them to service. Always follow manufacturer's instructions for these procedures.

**CAUTION:** Do not autoclave face masks. Autoclaving causes rapid deterioration of face mask cushions.

#### **Cleaning and Disinfecting the Y-Piece and Mask**

The Y-piece and mask can be disinfected by wiping or immersion with glutaraldehyde-based formulations. EtO and wet pasteurization processes can also be used.

#### **Cleaning and Disinfecting the Ventilator Bellows**

The ventilator bellows and its bottom assembly are the only ventilator components that come in contact with the patient's breath. Refer back to "Cleaning and Disinfecting Exterior Surfaces" for instructions on cleaning and disinfecting the surface of the ventilator bellows assembly.

Clean the bellows with a soft lint-free cloth moistened with mild alkali detergent and water, followed by a distilled water rinse. Let the bellows drip dry.

After cleaning, use wet pasteurization at 70°C for 30 minutes, a glutaraldehyde-based solution, or an EtO process to disinfect the ventilator bellows. Follow manufacturer's guidelines for these procedures.

#### **Cleaning and Disinfecting the Ventilator Bellows Bottom Assembly**

Clean the ventilator bellows bottom assembly with a soft lint-free cloth moistened with mild detergent and water, followed by a distilled water rinse. Allow the assembly to drip dry.

After cleaning, use an EtO process for disinfection. Follow manufacturer's guidelines.

#### **Cleaning and Disinfecting the Oxygen Sensor Capsule**

Wipe the oxygen sensor capsule with a soft lint-free cloth moistened with mild detergent and water. Make sure the capsule is dry before replacing it.

**CAUTION:** Do not immerse or autoclave the oxygen sensor capsule.

After cleaning the capsule, perform an EtO process at a temperature not exceeding 50°C. Aerate the sensor according to the manufacturer's instructions.

**Cleaning and Disinfecting the Oxygen Sensor Housing**

The oxygen sensor housing can be immersed for cleaning and disinfection. Use mild detergent and water for cleaning. For disinfection, follow up with either sodium hypochlorite (5.2% household bleach) 1:500 dilution (100 ppm free chlorine) or 70% to 90% ethyl or isopropyl alcohol.

**Cleaning and Disinfecting the Oxygen Sensor Housing Cover**

The oxygen sensor housing cover can be immersed or wiped during cleaning and disinfection. Use mild detergent and water for cleaning. For disinfection, follow up with a 2% glutaraldehyde-based formulation, wet pasteurization at 70°C for 30 minutes, or an EtO process.

**Cleaning and Disinfecting the Inspiratory and Expiratory Valves**

The inspiratory and expiratory valves come into contact with the patient's breath. Clean these parts with soft lint-free cloth moistened with mild alkali detergent and water. Dry the parts before reassembling. The valve assemblies can be immersed in a 2% glutaraldehyde-based solution, wet pasteurized, gas sterilized, or autoclaved at a temperature not exceeding 121° C. The valve disks can also be autoclaved in certain instances, but should not be autoclaved routinely.

Be careful while handling the valve disks. Improper handling can damage them. After cleaning or disinfecting the inspiratory or expiratory valve assembly, verify that the valve disk and all internal pins are undamaged and that the valve disks are correctly reinstalled.

**Cleaning and Disinfecting the Ultrasonic Flow Sensor Housing and Transducers**

Wash the flow housing and transducers with mild detergent and water. Follow with a distilled water rinse. These components can be immersed.

The flow housing and transducers can be autoclaved at a temperature not exceeding 121°C. Follow the autoclave instructions for the process. Allow the transducers to normalize for 30 minutes under room ambient conditions before using them.

**Cleaning and Disinfecting the Ultrasonic Flow Sensor Electronics Housing and Cable**

Wipe the electronics housing and sensor cable with a clean, soft cloth moistened with mild detergent and water. Take care not to allow any fluid to access the interior of the electronics housing.

The electronics housing and sensor cable can be wiped with a clean, soft, lint-free cloth moistened with a 70% to 90% diluted solution of ethyl or isopropyl alcohol or sodium hypochlorite (5.2% household bleach) at 1:500 dilution (100 ppm chlorine).

**NOTE:** Draeger Medical makes no claims about the efficacy of these agents or this method of cleaning for infection control. Consult your hospital's infection control officer or epidemiologist.

**Cleaning and Disinfecting the Breathing System Pressure Gauge**

Wipe the pressure gauge assembly with a soft lint-free cloth moistened with mild detergent and water. Dry the assembly before reinstalling.

The gauge can be disinfected with ethylene oxide gas, followed by appropriate aeration. Follow the manufacturer's instructions.

**CAUTION:** The breathing system pressure gauge cannot withstand immersion or the heat and pressure of autoclaving.

**CAUTION:** The MRI-2 breathing system gauge is MRI-compatible. When disinfecting the gauge with other Draeger Medical breathing pressure gauges, be sure to return the MRI-compatible gauge to the MRI-2 anesthesia unit.

**Cleaning and Disinfecting the Absorber Canister Assemblies and Dust Cup**

Refer to the instructions provided earlier in this chapter under the heading, "Replacing the Absorbent" for instructions on removing the absorbent canister assemblies from the absorber.

Clean the canisters frequently. Remove used absorbent and clean absorbent residues for the canister and gasket surfaces. Check the dust cup periodically. Empty and clean it when necessary.

**WARNING:** Absorbent is caustic. Avoid contact with the skin and eyes.

After removing the canister assemblies and dust cup from the absorber system, wash these parts with mild alkali detergent and water. The canister assemblies and dust cup can be immersed or wiped with a soft lint-free cloth. Allow the parts to dry.

Several methods can be used for disinfection. Wet pasteurization, autoclaving, EtO, and immersion or wiping with 2% glutaraldehyde-based solution are all acceptable. If an EtO process is used, make sure the parts are properly aerated before returning them to service.

**Cleaning and Disinfecting the Absorber Assembly**

Turn the APL valve control knob fully counterclockwise before cleaning or disinfecting the absorber system.

After cleaning, an EtO procedure can be used. Follow manufacturer's guidelines.

**CAUTION:** Do not autoclave the absorber assembly.

### **Cleaning and Disinfecting the Vaporizer Exterior**

Clean the vaporizer with a soft lint-free cloth moistened with mild detergent and water. Follow up with a 70% to 90% diluted solution of ethyl or isopropyl alcohol or sodium hypochlorite (5.2% household bleach) at 1:500 dilution (100 ppm chlorine). Do not sterilize the vaporizer.

**WARNING:** Water and other liquids (with the exception of the appropriate anesthetic) that enter the vaporizer chamber can cause injury to the patient or form corrosive products that affect the function of the vaporizer.

**CAUTION:** Do not immerse the vaporizer or allow water or any other liquid to enter the fill or drain ports or fresh gas inlet or outlet ports. Any vaporizer suspected of contamination with water or any other liquid must be returned to DrägerService for a complete overhaul.

Additional care must be taken with halothane vaporizers. Halothane contains a stabilization additive called thymol, which evaporates more slowly than halothane, and collects in the vaporizer. Over time, thymol may decompose into compounds that affect the wick material and turn the halothane yellow.

If you see particles in the sight glass of a halothane vaporizer, or if the halothane turns yellow, rinse the vaporizer chamber with fresh halothane as follows:

1. Drain the discolored halothane from the vaporizer.
2. Fill the vaporizer with fresh halothane up to the maximum level, then drain completely.
3. Dispose of the drained halothane in accordance with standard practices at your facility.

For information about filling and draining the vaporizer, see the appropriate separate manual supplied with vaporizers that are available for use with the Narkomed MRI-2.

### **Cleaning and Disinfecting the Open Reservoir Scavenger**

The scavenger interface does not normally need to be disinfected. However, if the user facility requires disinfection, an EtO process can be used after cleaning. Refer back to the cleaning instructions provided under the "Routine Maintenance" section in this chapter.

**CAUTION:** Do not autoclave the open reservoir scavenger. The scavenger's flowmeter cannot withstand the heat of autoclaving.

### **Cleaning and Disinfecting the Passive Scavenger Interface**

The scavenger interface does not normally need to be disinfected. However, if the user facility requires disinfection, an EtO process can be used after cleaning. Refer back to the cleaning instructions provided under the “Routine Maintenance” section in this chapter.

**CAUTION:** Do not autoclave the scavenger interface for passive systems. The scavenger's relief valves cannot withstand the heat of autoclaving.

### **Disinfecting the Scavenger Hoses**

The scavenger hoses are not part of the breathing circuit, so they do not require disinfection. If the user facility requires disinfection, refer back to the instructions provided in “Cleaning and Disinfecting Corrugated Breathing Hoses, Mask Elbow, and Bag” to select a compatible process.

Check the hoses frequently for signs of deterioration, including swelling tackiness, or cracking. Replace the affected parts when any of these conditions are evident.

## **Reassembly Instructions**

Make sure all parts are complete dry and adequately aerated before reassembling the machine after cleaning and disinfection procedures.

1. Reassemble the ventilator bellows assembly. Fit the relief valve dome onto the relief valve body, and tighten the knurled ring nut. Place the ventilator bellows on bellows bottom assembly and turn it clockwise until it is secure.
2. Replace the bellows assembly. Fit the bellows assembly into the ventilator bellows canister and tighten the two wing nuts.
3. Replace the absorber. Fit the absorber assembly on the absorber pole, making sure the o-ring is in place. Use a 3/16-inch hex screwdriver to tighten the hex screw securing the absorber system assembly to the absorber pole.
4. Replace the pressure gauge. Place the pressure gauge assembly on the gauge mount, making sure that the o-ring is in place between the pressure gauge assembly and the gauge mount. Slide the knurled ring nut over the threads on the gauge mount. Turn the knurled ring nut clockwise until it is secure. Check the gauge needle's zero position and adjust it if necessary.
5. Replace the canisters and dust cup, making sure the gaskets and O-ring are in place. Pull the canister lever up until it clicks in place.
6. Reassemble the inspiratory and expiratory valves. Place the valve disk and dome gasket in the valve body, then replace the dome and ring nut. Turn the ring nut clockwise to tighten.
7. Replace the inspiratory valve assembly and gasket on the valve mount. Turn the valve assembly clockwise to secure it to the valve mount.

8. Replace the expiratory valve assembly and gasket on the absorber. Turn the valve assembly clockwise to secure it to the absorber dome.
9. Reassemble the ultrasonic flow sensor. Press the transducers into their ports on the flow housing. Ensure that the three O-rings on each transducer are not damaged and are properly seated. Slide the flow housing/transducer assembly into the electronics housing. Be sure that it clicks into place.

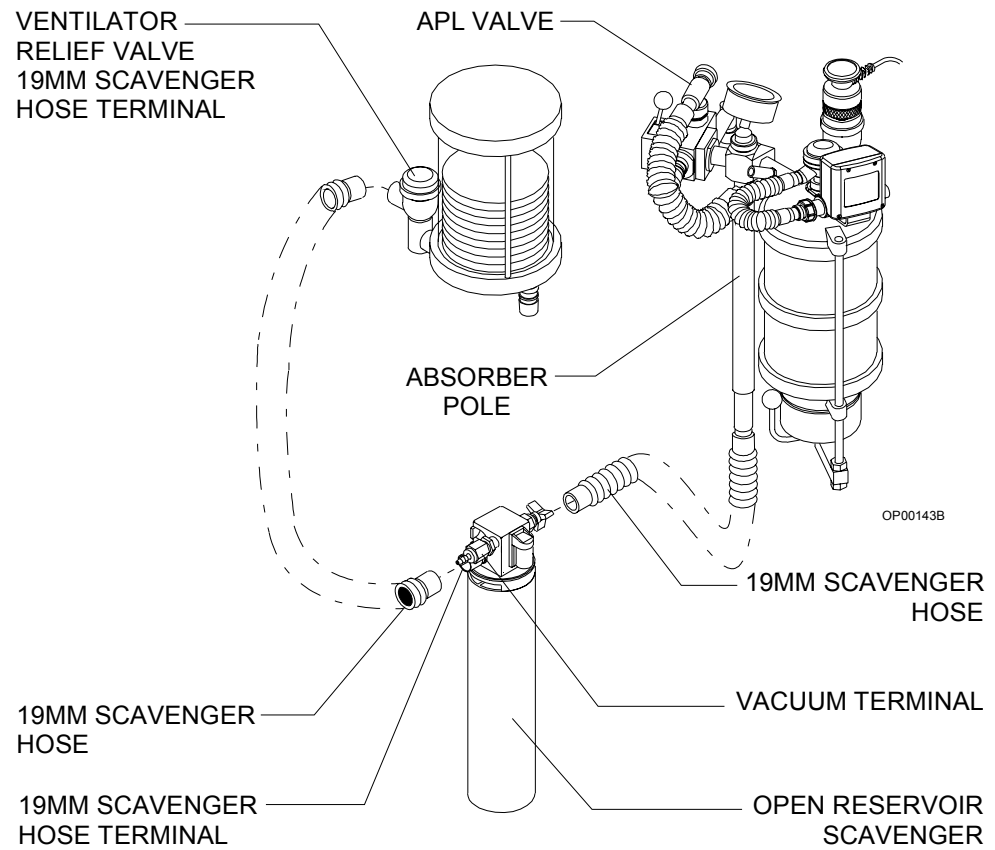
**NOTE:** If the flow housing/transducer assembly does not fit easily into the electronics housing, make sure the flow housing is facing the right direction. Compare the direction to the illustration on the electronics housing. The index pin on the electronics housing should align with the hole in the flow housing.

10. Slide the flow sensor onto the bracket.
11. Connect the patient hose to the expiratory hose terminal on the flow sensor.
12. Install the connector hose assembly between the flow sensor and the expiratory valve, and secure it by turning the ring nut clockwise.
13. Replace the oxygen sensor in the inspiratory valve port. Connect the sensor cord to the monitor.
14. Connect the fresh gas hose to the fresh gas outlet on the machine.  
**WARNING:** Do not pinch or kink the fresh gas hose leading from the fresh gas outlet to the absorber.
15. Reconnect the breathing pressure pilot line to the absorber and the monitor.
16. Replace the 22 mm hoses and other breathing circuit accessories.
17. Replace the 19 mm hose that connects the APL valve to the absorber pole.
18. Replace the 19 mm hoses that connect ventilator relief valve and absorber pole to the scavenger as illustrated in the following drawings. If the scavenger hoses were removed from the scavenger, replace the scavenger hoses as illustrated on the following pages.

19. Turn the SYSTEM POWER switch to ON.
20. Perform the daily checkout procedure provided in this manual before operating the machine.

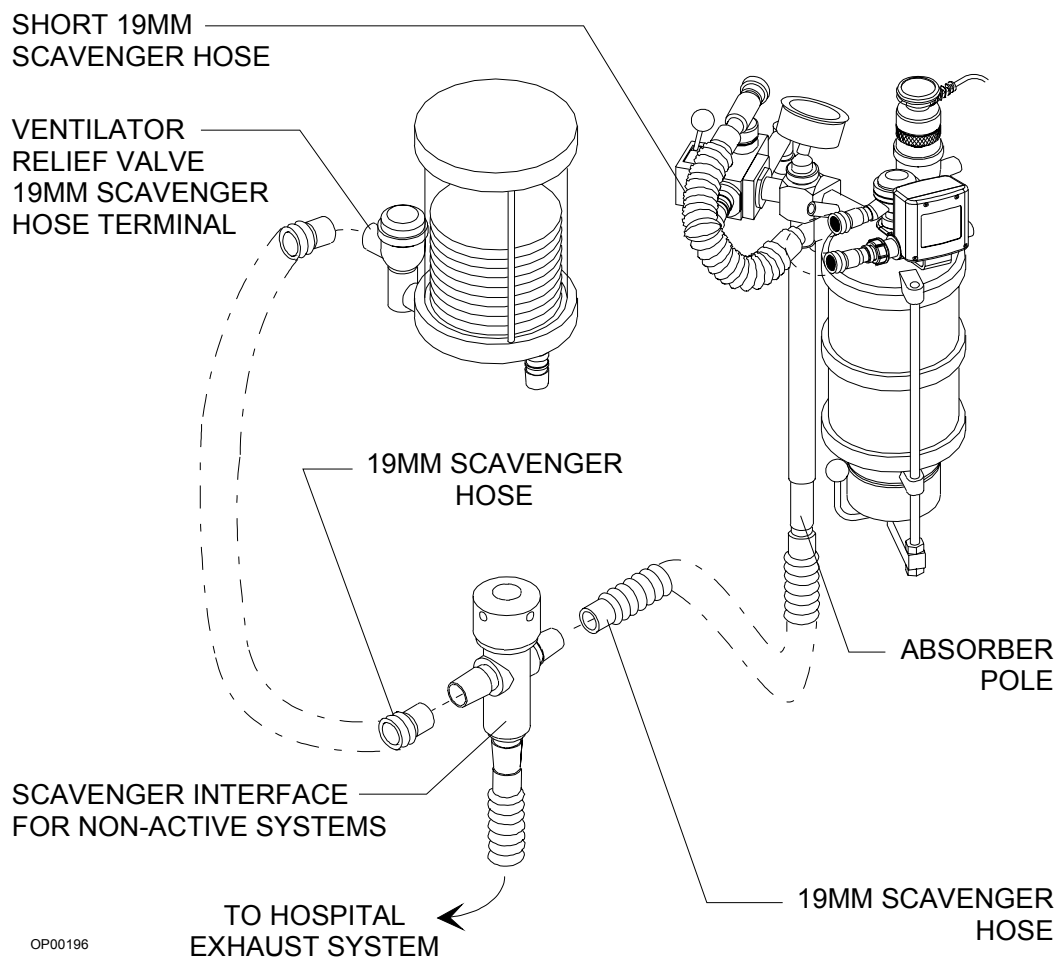
## Open Reservoir Scavenger Connections

Figure 14-10. Open Reservoir Scavenger Connections



## Passive Systems Scavenger Connections

Figure 14-11. Passive Systems Scavenger Connections



# 15

## Specifications

*This section describes the specifications of the Narkomed MRI-2 anesthesia machine.*

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## General

Dimensions (W x H x D) . . . . .	31½ x 53¼ x 27 inches
Weight (approximates) . . . . .	anesthesia machine 230 lbs remote battery charger 3 lbs

## Environmental

<b>Operating</b>	Temperature . . . . .	50–95°F
	Humidity . . . . .	30–75% relative humidity (noncondensing)
	Barometric Pressure . . . . .	787 to 523 mmHg
<b>Storage</b>	Temperature . . . . .	14–122°F
	Humidity . . . . .	10–90% relative humidity (noncondensing)
	Barometric Pressure . . . . .	787 to 523 mmHg

## Electrical

	Equipment class . . . . .	IEC 601 Class 1, Type B, Continuous operation, IPX0, non-APG
	Leakage current. . . . .	≤ 300 microamps (UL 544)
	Ground impedance . . . . .	≤ 0.1 ohm (60 Hz source)
	Dielectric withstand (mains to chassis). . . . .	1500 VAC (UL 544)
	Charger chassis resistance (between any metallic point and ground pin on power cord) . . . . .	≤ 0.1 ohm (on AC powered component)
<b>Power Supply</b>	Nominal input voltage (acceptable range). . . . .	100–240 VAC @ 50/60 Hz
	Input current . . . . .	2 amps max
<b>Battery</b>	Battery type. . . . .	sealed lead acid, 12 VDC, 17 AH
	Charging time. . . . .	≤ 16 hours
	Reserve power time (from full charge) . . . . .	≤ 3 hours

## Gas Delivery System

Pipeline inlet connections. . . . .	DISS/male Nut with nipple (Canada)
Pipeline inlet pressure . . . . .	50–55 psi (345–380 kPa) (O <sub>2</sub> , N <sub>2</sub> O, Air)
Pipeline gauge accuracy . . . . .	±3 psi (0–25 psi) ±2 psi (26–75 psi) ±3 psi (76–100 psi)

Cylinder connections. . . . .	Pin-indexed hanger yokes (CGA V-1-1994)
Over-pressure relief valve . . . . .	95 psi (655 kPa)
Over-pressure relief valve (Canada) . . . . .	75 psi (520 kPa) (CSA Standard Z168.3-M84)
Fresh gas common outlet . . . . .	15 mm female (Canada: 15 mm female, 22 mm male)
Fresh gas oxygen concentration (ORC) . . . . .	25 ±4%
Oxygen flush flow rate . . . . .	55 (±10) l/min
Minimum oxygen flow (at 50 psi pipeline pressure) . . . . .	150 ±50 ml/min
Low oxygen supply pressure alarm . . . . .	34–40 psi
Cylinder gauge accuracy. . . . .	±90 psi (0–750 psi) ±60 psi (750–2250 psi) ±90 psi (2250–3000 psi)

**Cylinder Gas Pressures (typical full loads at 70°F, 21°C)**

Oxygen. . . . .	1900 psi (13100 kPa)
Nitrous oxide. . . . .	745 psi (5130 kPa)
<i>Use only E-size nonmagnetic (aluminum) cylinders</i>	

**Flowmeter Accuracy (at 20°C and 760 mmHg)**

Oxygen, Nitrous Oxide, Air (Fine) . . . . .	100–1000 ml/min ±2.5% FS
Oxygen, Nitrous Oxide, Air (Coarse) . . . . .	1–10 l/min ±2.5% FS
Air (Dual Tapered) . . . . .	0.2–1 l/min ± 50 ml/min of reading 2–10 l/min ±5% FS
Carbon Dioxide . . . . .	0.05–1.0 l/min ±5% FS
Oxygen (Auxiliary Oxygen) . . . . .	1–10 l/min ±5% FS

**Vaporizers**

For technical specifications for vaporizers available for use with the Narkomed MRI-2, see the appropriate separate manual.

**AV2+ Ventilator**

Frequency . . . . .	1–99, ±1 BPM (in 1 BPM increments)
I:E ratio . . . . .	<i>Standard range:</i> 1:1–1:4.5, ±0.1 (in increments of 0.5); <i>Extended range:</i> 4:1, 3:1, 2:1
Inspiratory flow. . . . .	10–100 l/min (uncalibrated)
Tidal volume . . . . .	20–1500 ml, ±100 ml
Pressure limit control adjustment range. . . . .	15–120 cmH <sub>2</sub> O

## Absorber System

<b>Inspiratory Valve</b>	Mounting ring nut size . . . . .	M35 x 1
	Hose terminal . . . . .	22 mm male
<b>Expiratory Valve</b>	Mounting ring nut size . . . . .	M33 x 1
	Hose terminal . . . . .	22 mm male
<b>Breathing System Pressure Gauge</b>	Range . . . . .	-20 to +80 cmH <sub>2</sub> O
	Smallest scale division . . . . .	2 cmH <sub>2</sub> O
	Nominal accuracy . . . . .	-20 to +5 cmH <sub>2</sub> O: 3% FS
		+5 to +55 cmH <sub>2</sub> O: 2% FS
		+55 to +80 cmH <sub>2</sub> O: 3% FS
	Mounting ring nut size . . . . .	1 1/8 x 18
<b>APL Valve</b>	Nominal low flow resistance . . . . .	2 cmH <sub>2</sub> O at 8 l/min
	Hose terminal . . . . .	19 mm male
<b>Breathing Bag Terminal</b>	Bag terminal . . . . .	22 mm male

## Oxygen Monitoring

Range . . . . .	10–100 vol % O <sub>2</sub>
Resolution . . . . .	1 vol % O <sub>2</sub>
Accuracy . . . . .	±3 vol % O <sub>2</sub>
(When calibrated within 18 hours, and constant temperature and pressure)	
Response time . . . . .	≤ 25 sec (T <sub>90</sub> )
Zero drift . . . . .	≤ 0.1 vol % O <sub>2</sub> /month
Span drift . . . . .	≤ 1 vol % O <sub>2</sub> /8 hours
Temperature error . . . . .	≤ ± 3% of reading (15° to 40°C)
Sensor service life . . . . .	≥ 8 months at 25°C, 50% relative humidity, 50% O <sub>2</sub> gas mixture (or ≥5000% hour CO <sub>2</sub> )

## Breathing Pressure Monitoring

Numeric display range . . . . .	-10–125 cm H <sub>2</sub> O
Resolution . . . . .	1 cm H <sub>2</sub> O
Accuracy . . . . .	±3 cm H <sub>2</sub> O or ±10% of reading,

	whichever is greater
Waveform display range - full . . . . .	0–100 cm H <sub>2</sub> O
Waveform resolution . . . . .	1 cm H <sub>2</sub> O
Waveform accuracy . . . . .	±3 cm H <sub>2</sub> O or ±10% of reading, whichever is greater
Waveform display scales . . . . .	0–20, 0–50, 0–100 cm H <sub>2</sub> O

## Respiratory Volume Monitoring

<b>Minute Volume</b>	Display Range . . . . .	0.1–50.0 l
	Resolution . . . . .	0.1 l
	Accuracy . . . . .	10% of reading or 0.01 l x breath rate, whichever is greater*
<b>Tidal Volume</b>	Display Range . . . . .	0.01–2.0 l
	(Note: the standard bellows will deliver up to 1.5 l)	
	Resolution . . . . .	0.01 l
	Accuracy . . . . .	10% of reading or 0.015 l, whichever is greater*
	Volume Apnea Threshold . . . . .	0.02 l
<b>Respiratory Rate</b>	Numeric display range . . . . .	2–99 bpm
	Resolution . . . . .	1 bpm
	Accuracy . . . . .	±10% of reading or 1 bpm, whichever is greater

\*exclusive of hose compliance effects

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# A

## Appendix Spare and Replacement Parts

*This section describes the spare and replacement parts for the Narkomed MRI-2 anesthesia machine along with their part numbers.*

**A**

Appendix Spare and Replacement Parts

	Description	Part Number
<b>Manuals</b>		
	Narkomed MRI-2 Binder and Instruction Assembly . . . . .	4114977
	Narkomed MRI-2 Technical Service Manual. . . . .	4114210
	Narkomed MRI-2 Setup and Installation Manual . . . . .	4114976
<b>Absorber System</b>		
	Gasket - Canister Top . . . . .	4105848
	Gasket - Canister Bottom . . . . .	4105849
	Gasket - Absorber Bottom . . . . .	1101001
	Screen - Canister . . . . .	1100022
	Canister . . . . .	4105852
	Breathing Pressure Gauge Assembly . . . . .	4105853-001
	Dome - Inspiratory/Expiratory Valve (no port) . . . . .	2109230
	Dome - Inspiratory Valve (with sensor port) . . . . .	4108329
	Plug Assembly - (for inspiratory valve dome with sensor port) . . . . .	4106837
	Valve Assembly - Inspiratory (with ported dome assembly and plug assembly) . . . . .	4107649
	Valve Assembly - Expiratory . . . . .	4107650
	Ring Nut (inspiratory or expiratory valve upper ring nut) . . . . .	2109228
	Gasket (flat washer, inspiratory or expiratory valve mount) . . . . .	1101690
	Dust Cup . . . . .	4106874
	Spring Clip (absorber rod) . . . . .	1100097
	O-ring #020, Silicone (absorber mount) . . . . .	4105868
	O-ring #237, Silicone (dust cup fitting) . . . . .	4102940
<b>Breathing System Accessories</b>	Breathing Hose, 22 mm x 23" long. . . . .	9995123
	Breathing Hose, 22 mm x 32" long. . . . .	9995132
	Breathing Hose, 22 mm x 40" long. . . . .	9995140
	Rubber Good Set (includes Y-Piece, Mask Elbow, 2 Liter Breathing Bag, and 2 each 32" Breathing Hoses . . . . .	1101071
<b>Gas Evacuation Accessories</b>	Hose, 19 mm x 10" long . . . . .	9995210
	Hose, 19 mm x 20" long . . . . .	9995220
	Hose, 19 mm x 30" long . . . . .	9995230
	Hose, 19 mm x 48" long . . . . .	9995248

	Description	Part Number
<b>Breathing Bags</b>	2.0 liter .....	9995320
	5.0 liter .....	9995350
<b>Bellows</b>		
	Adult Latex-Free Bellows.....	4106930-001
<b>Tracheal Suction System</b>		
	Suction System Assembly.....	4106328-002
<b>Oxygen Monitoring Accessories</b>		
	Oxygen Sensor Capsule .....	6850645
	Sensor Housing & Cable Assembly .....	4115351
	Inspiratory Valve Dome .....	4108329
	Inspiratory Valve Dome Plug.....	4106387
<b>Respiratory Volume Monitoring Accessories</b>		
	Flow Sensor Assembly (MRI-2) .....	4116236
	Connector Hose Assembly .....	4114912
	Flow Housing .....	4114444
	Transducer Set .....	4114445
	O-ring Set .....	4115147
<b>Power Supply Accessories</b>		
	52 foot ASM-MRI-2 power cable.....	4114158
	6 foot ASM power cord .....	4110334
	Battery, 12V rechargeable .....	4111957
	Power Supply Relocate Assembly - MRI-2 (Filter Box) .....	4114946

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